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## Parasitological and Other Problems in Sheep in Western Australia.

*By I. Clunies Ross, D.V.Sc.**

The Officer-in-Charge of the Council's F. D. McMaster Animal Health Laboratory (Dr. I. Clunies Ross) recently visited Western Australia to study certain sheep problems which had been believed to be due mainly to the action of internal parasites (worms). He has now submitted a report on his observations, and in it he shows the importance of good nutrition, as distinct from drenching, as a means of overcoming the effects of certain parasites. From that point of view, it is considered the report will be of somewhat general interest. In a slightly condensed form it is accordingly published below.—Ed.

*Introduction.*

During recent years, considerable difficulty has been experienced in rearing young Merino sheep in the Midland and Great Southern Districts of Western Australia. Some indication has been obtained that increasing prevalence of worm parasites is an important factor in the causation of this trouble. It was to test this point, if possible, that my visit was made.

### 1. Districts Visited.

During the first part of my tour, visits were paid to various properties in the country lying between Toodyay and Coomberdale in the Midland District, the latter town lying about 120 miles north of Perth. During the second week, visits were paid to properties in the vicinity of York, Northam, Goomalling, Narrogin, and Wickepin, in the Great Southern District. Finally, a brief inspection was made of the Denmark Area in the far south. The purpose of the latter visit was not connected with the main object of my visit.

### 2. History of Trouble in Young Sheep.

On the majority of properties visited, there was a history of increasing difficulty in rearing young sheep, particularly during the past two or three years. In connexion with the lambs dropped in 1931, considerable evidence of worm infestation was shown during the autumn of 1932, and on many properties intensive drenching against worm

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parasites had been carried out for the first time. It was found, however, that, in addition to evidence of worm infestation and the more acute evidences of ill-health seen in young sheep, there appeared to be a general tendency for aged sheep to be less productive than they had been in previous years, as shown by a general tendency for wool production to decrease. It was commonly considered, also, that there had been a decrease in the carrying capacity of a number of properties over the last three years. During the present year, the lambing percentage on the majority of properties visited was extremely poor. This was attributed partly to the poor condition of lambing ewes and the relatively late rains, but also to the extraordinarily heavy rains which took place at, and subsequent to, lambing. It was also found that during recent years there had been a considerable increase in the incidence of osteophagia (bone chewing) and sarcophagia (carrion chewing) shown by both cattle and sheep in many properties in the districts visited. The resultant appearance of botulism (toxic paralysis) had apparently led to the loss of many thousands of sheep of all ages, but particularly lambing ewes and lambs, in addition to many hundreds of cattle. Another factor which had to be taken into consideration in relation to the troubles experienced, was the very serious increase in the number of rabbits which, during recent years, had been such that the rabbit has become a definite and very serious problem.

### 3. The Farming Practice in the Affected Areas.

Practically all properties visited were of a mixed farming type, a considerable proportion of all properties being farmed, the principal crops grown being wheat and oats. Certain properties still contained a considerable area of natural grazing country, while one property in the York district was almost entirely cropped or laid down in improved pastures. The standard of sheep management varied very greatly in the properties visited, particularly in regard to the amount of supplementary feeding of sheep carried out. In general, it appeared to be the accepted practice to feed lambing ewes from one month to six weeks before lambing, and subsequent to lambing up to the time of the first rains. On only a minority of properties, however, was it a regular practice to feed lambs after weaning, although during 1932 a considerable amount of supplementary feeding had been carried out after the lambs had developed marked symptoms of parasitic infestation. On a number of properties, the tendency appeared to be to regard the sheep rather as a scavenger, or at least as a means of cleaning up fallow and of feeding off wheat stubbles.

The use of phosphatic licks was not general, although there seemed to have been a very considerable increase in their employment following recent outbreaks of toxic paralysis (botulism) and their advocacy by the Western Australian Department of Agriculture. The type of lick used was generally satisfactory, being approximately 40 to 50 per cent. dicalcic phosphate. There seemed, however, to be a considerable tendency not to put out licks until rather late in the summer, instead of having them available from late spring onwards, if not throughout the whole year.

On certain highly improved properties, the standard of sheep management appeared to be very high, and every care was taken to supply

supplementary feeding, either in the form of special oat or other crops, or in the form of oaten hay with peas or clovers mixed with it. These properties also have laid down extensive improved pastures in subterranean clover and Wimmera rye grass, and there is no doubt that nutritional conditions should be entirely satisfactory, but for the recent depredations of the lucerne flea and the red-legged earth mite.

In the majority of properties, lambing was carried out from May to June, though in exceptional cases lambing was commenced as early as April. Lambs appeared to be weaned most frequently after the beginning of November. The carrying capacity of the usual type of mixed farm appeared to be in the nature of one sheep to 3 acres or one sheep to 2 acres, and only in very exceptional cases, where pasture improvement had been intensively employed, was there any suggestion that the carrying capacity of a sheep per acre could be attempted.

## 4. Evidences of Parasitism at the Time of My Visit.

Sheep were killed and examined post mortem on fourteen properties in the Midland and Great Southern Districts, special attention being devoted to the present season's lambs. As was expected, the type of parasitic fauna found was of the winter rainfall type common to the southern regions of the Commonwealth. Very little evidence of the presence of the large stomach worm, *Haemonchus contortus,* was obtained, this parasite being found on only three properties, and in only one lamb did it occur in any numbers. The medium stomach worm, *Ostertagia circumcincta,* was extraordinarily common, though in no instance was any heavy infestation met with. In the small intestine, *Trichostrongylus* spp. (*T. vitrinus* and *T. instabilis*) were present in every case examined, though in general infestations were light. In certain cases, however, both in the Midland and Great Southern Districts, moderate infestations occurred. In one instance, the infestation was sufficiently heavy to be of some pathological importance in the event of the affected lambs being subjected to adverse nutritional conditions. The thin-necked intestinal worm, *Nematodirus* spp. was also moderately common, but, in all cases in the Midland District, only light infestations were met with, and only on rare occasions were moderate infestations seen in the Great Southern District. The large bowel worm, *Chabertia ovina* was extremely common throughout in lambs, and not infrequently marked lesions due to this parasite were seen. In only one instance was infestation encountered with the tape worm, *Moniezia* spp., or the whip worm, *Trichuris ovis.* It must be remembered that in all cases the worst lambs were selected for post mortem examination, so that it is probable that the general degree of infestation throughout the flocks was lighter than is indicated by these examinations.

## 5. Discussion of Probable Importance of Several Factors Contributing to Weaner Trouble.

(i) *Nutritional Factors.*

The factor of primary importance to be considered in assessing the importance of various subordinate influences is the prolonged dry period which is almost universally experienced in the affected districts from the beginning of November until the end of April. During this period,

other than thunder showers of negligible value, no rain falls. (The rainfall on the majority of the properties visited was 16 to 18 inches a year.) As a result, there is a liability to serious nutritional deficiency, owing to the very marked fall in the nutritive value of pastures from November onwards. Certain pasture analyses by the Department of Agriculture, Western Australia, testify to the seriousness of the fall in protein and minerals even at the beginning of the summer months. It has to be realized that, on the majority of properties, there is almost certainly a very serious protein and phosphorus deficiency during the later summer and autumn months. Where supplementary feeds are grown, this may in part be corrected by feeding good oaten and clover hay, but in those instances where sheep are confined to natural pasture, or are run on wheat stubbles, such nutritional deficiency may be expected to take its most severe form. Just how intense the demand for supplementary minerals may be is shown by the consumption by 2,500 weaners on a Toodyay property of 1 ton of lick in nine days, equivalent to almost 2 ozs. per head per day. It is probable that such deficiency, owing to the relatively high rate of stocking carried, is more apparent than it was when such country was in its natural state and run under ordinary conditions of sheep grazing. At that time, owing to the low rate of stocking, the sheep could practise a certain amount of selective grazing.

On stubble country, the predominating pasture types throughout the greater part of the area visited appeared to be barley grass (*Hordeum murinum*) and wild oat (*Avena fatua*), both being considered to be very poor fodders except in the young growing stage, and a certain amount of silver grass and *Bromus* spp. There was also a certain amount of small indigenous clovers, the ball clover (*Trifolium procumbens*) and hop clover (*Trifolium glomeratum*), and a very small amount of burr trefoil (*Medicago denticulata*). Though it might be expected that where small natural clovers were plentiful nutritional conditions might not be as extreme as is indicated above, there is little definite evidence of the food value of such clovers, although the small size of the seed would indicate that they are relatively much less valuable than such a clover as substerranean clover.

As accentuating what is a normal seasonal deficiency in these areas in Western Australia, the rabbit must be considered as a very important additional factor in recent years. There seemed to be general agreement amongst farmers that, concurrently with the increase in the rabbit population, their trouble in sheep of all ages appeared to increase. There was also agreement that the rabbit had led to a very serious decrease in the amount of ground feed, particularly clovers, which might be expected to provide a more nutritive ration. In one property, 11,000 acres of scrub country had been rendered entirely useless by the rabbits. On another property of 13,000 acres, some 20,000 rabbits had been caught in the six weeks preceding my visit, and it was thought that at least an equal number were still alive. Forty thousand rabbits might be expected to consume the feed of 4,000 sheep. The seriousness of this on a 13,000 acre property need not be stressed. There is little doubt, also, that in the wheat stubbles the rabbits would take a large part of the grain, which is the main part of such stubble feed.

*The Increasing Severity of Osteophagia.*

The increasing severity of nutritional deficiency shown in recent years is evidenced by the growing seriousness of osteophagia. On a number of properties, particularly in the Midland District, there was a history of evidence of extreme osteophagia being shown both by old and young sheep, which would eat not only rabbit bones, but also worry and eat whole rabbit carcasses. Frequently sheep would eat rabbit droppings with equal avidity. Similar symptoms were shown by cattle, and since the development of these tendencies, very heavy mortality has been experienced; this has been diagnosed by officers of the Department of Agriculture, Western Australia, as being due to botulism. On one property visited, over 300 out of 500 weaners had died from this cause, while figures of almost equal severity were cited on other properties.

(ii) *Parasitism.*

It is considered that, having regard to the climatic conditions experienced in the areas visited, almost the whole worm infestation acquired by young sheep during their first year would be limited to the months from May to November, during which period wet conditions are met with. Following the cessation of rains, it is thought that only in rare instances would a further infestation of any considerable degree be acquired. Contrary to general belief, it is thought that young sheep showing evidences of worm infestation in the later summer and autumn months did so, not as a result of acquiring further infestation during this period, but rather to their exhibiting the effects of the infestation acquired in the winter months, which infestation they had continued to harbour.

So far as the present season's lambs are concerned, it is not considered that their degree of worm infestation is sufficiently heavy to be a serious factor in any symptoms shown later, in the summer or in the autumn of 1934. The possibility cannot be disregarded, however, that in exceptional years having long mild winters, with the rains well distributed over the winter and spring, infestation might reach a sufficient degree to be the primary cause of serious trouble.

It is considered that the small Trichostrongyles (particularly *Trichostrongylus* spp.) are the more serious factor in the causation of loss from parasitic infestation, but the importance of the large bowel worm, *Chabertia ovina,* can by no means be overlooked.

An important factor often determining the production of serious loss through parasitic infestation is not so much the degree of infestation met with under normal conditions, but rather the severity of nutritional conditions to which the young sheep are subjected. In short, it is considered that in the districts visited parasitic infestation is rather a secondary than a primary cause of loss, and that the more important factors to be considered are nutritional in nature. In this connexion, it may be mentioned that recent experimental work has shown that the nutritional state of an animal, particularly a young sheep, is of fundamental importance in determining the effects of a given degree of infestation, as also as largely determining the degree of the infestation set up. On this point, it is interesting to remember the

insistence which the Chief of the Division of Animal Health, Dr. J. A. Gilruth, has for many years past placed on adequate nutrition as a means of controlling loss from parasitic infestation.

Under normal and adequate nutritional conditions, young sheep which are exposed, as are those in South-western Australia, to infestation up till the end of October, should, provided the degree of infestation is not excessive, begin to develop a resistance to worm parasites in the succeeding three or four months. By the autumn, therefore, they should have thrown off the infection acquired during the winter and spring. If, however, any severe nutritional stress is placed upon such lambs, the development of this natural resistance is completely prevented, and, indeed, what was a normal and relatively innocuous degree of infestation may become a serious factor in the production of disease.

The importance of the degree of parasitic infestation is increased by the fact that against the predominating type of infestation, known methods of treatment are much less effective than they are against the large stomach worm, *Haemonchus contortus*. Indeed, it is doubtful whether repeated drenching of lambs after weaning time is justified by results. Were effective treatment possible, there is little doubt that, following weaning of lambs in November and the advent of dry weather, all risk of trouble from parasitic infestation could be obviated by one or two drenchings following this period. The possibility must also be borne in mind that repeated and ineffective drenching may not only lead to unnecessary expense, but may also have a definitely harmful effect upon the sheep.

## 6. Conclusions as to the Nature of the Factors Involved.

(1) The problem of satisfactorily rearing young sheep in the Midland and Great Southern Districts is primarily nutritional in origin.

(2) Grave danger exists in the great majority of properties in the affected areas of serious deficiency in protein and essential minerals during the late summer and autumn.

(3) Such deficiency has been greatly augmented during recent years by the rabbit invasion.

(4) Parasitic infestation appears to be a factor of secondary importance, its importance depending largely on the nutritional state of young sheep.

(5) Osteophagia (bone chewing) and sarcophagia (carrion chewing), are also evidences of the general nutritional deficiency.

## 7. Recommendations.

(i) *The Value of Supplementary Feeding to Ewes and Young Sheep.*

Increased attention must be devoted to insuring a satisfactory state of nutrition of lambing ewes and lambs from the time of weaning onwards. This can be insured on a considerable proportion of the affected properties only by the growing of special supplementary crops for lambs, while continuing and increasing the present supplementary feeding supplied to lambing ewes. It is also particularly necessary

that not only should supplementary feeding of weaners be employed, but that such feeding should be begun before the lambs are seriously lowered in condition and their resistance to worm parasites correspondingly impaired. It must be stressed that, once lambs have begun to suffer mortality from the secondary effects of helminth parasites superimposed on their general low nutritional state, supplementary feeding may prove ineffective in quickly arresting the mortality. It is undoubtedly a sound economic policy to prevent the lowering of the resistance of lambs by beginning supplementary feeding at an early date, preferably educating them to this before weaning.

(ii) *The Possible Nature of Supplementary Feeding.*

The type of supplementary feeding best adapted to Western Australian conditions requires further investigation, and is a matter which demands early attention. One main difficulty would appear to be the supply of any supplement comparable to green fodder, which is particularly valuable to the young growing animal. The supply of good green oaten hay, of which the protein content is increased by harvesting with it subterranean clover, vetches, or peas, should prove of value. The possibility of supplying good quality silage might also be investigated, as certain farmers considered this would not be impracticable. The growing of special oat crops which the lamb should be allowed to harvest might also be borne in mind. Finally, more intensive laying down of permanent improved pastures might be considered. The evidence of the ability of early subterranean clover, Wimmera rye grass, and *Phalaris tuberosa* to establish themselves in Western Australia in areas having not more than 16 inches of rain is undoubted. The employment of supplementary feeds of high protein value, such as blood meal and meat meal, should also be investigated.

In addition to protein supplements, it should be regarded as an essential routine practice that satisfactory phosphatic licks, such as that recommended by the Department of Agriculture, Western Australia, should be freely available, particularly to lambing ewes and young growing sheep. The need for supplying such licks prior to the onset of the period of extreme mineral deficiency in the pastures should be stressed.

In connexion with the cost of supplementary feeding, it should be borne in mind that any expenditure involved must be considered in relation to the greatly enhanced price of wool and sheep. Expenditure which might have been economically unsound, having regard to the prices pertaining over the past three years, may, at the present time, be completely justified.

(iii) *The Possibility of Earlier Lambing and Weaning.*

Certain farmers appear to have experimented with earlier lambing in April instead of from May to June, as more generally employed, thus allowing lambs to be weaned in August or early September. Such a practice, though entailing somewhat longer supplementary feeding of lambing ewes, enables the lambs to be weaned on to pastures of which the nutritive value is still high. It is possible that this, by ensuring that the lambs are older at the time the nutritive value of the pastures begins to decline markedly, would increase their resistance to worm parasites. A controlled test of such earlier lambing might be carried out.

(iv) *The Rabbit Problem.*

Unless means are found of effectively controlling the rabbit pest, great difficulty may be experienced in restoring the carrying capacity of many of the properties visited, while certain of them will suffer very serious deterioration in the future. Every encouragement should be given to farmers to net their properties, as well as to erect subdivision netting. In view of the general employment of fumigation as a means of rabbit destruction, and in view of the very considerable expenditure in fumigating materials, a controlled test of the efficiency of this method should be carried out. Financial institutions should be impressed with the imperative need for financing the erection of rabbit proof fencing and rabbit destruction, if their equity is to be preserved.

(v) *Control of Parasitism.*

In spite of the lack of high efficiency of drenching against small stomach and intestinal worms, it is considered that a moderate degree of drenching is justified during the rainy period. Such drenching, however, should not be carried out more frequently than once every three weeks, and should not be begun with lambs less than six weeks to two months old. Lambs may be given a final drenching following weaning, when this takes place in November, or may be drenched at intervals until the onset of the dry period, when weaning is made earlier. It is not considered that any useful purpose is served by continuing routine drenching at frequent intervals throughout the summer, although one or two drenchings in the early summer months are justified owing to the possibility that some degree of infection with *Haemonchus contortus* may be carried concurrently with small Trichostrongyles. Against this parasite treatment is highly effective and therefore justified. The present policy should be to stress the necessity for so maintaining the nutrition of lambs that the serious effects of parasitism are prevented, rather than relying on treatment to effect any improvement, once such effects are shown, or actual mortality is being experienced. Where the winter has been abnormally wet or the rainy season unduly prolonged, special attention should be directed to the imperative need for additional nutritive precautions, owing to the greater risk of heavy infestation being set up under such conditions.

Confirmation of our opinion that no appreciable increase in the degree of parasitic infestation occurs during the dry summer and autumn should be sought by periodical examinations of lambs in the districts concerned.

## 8. Acknowledgments.

I have to thank Mr. G. L. Sutton, Director of Agriculture, and the officers of his Department for much assistance and information, and particularly the Chief Veterinary Surgeon, Mr. McKenzie Clark, for having made available the services of Dr. H. W. Bennetts and Mr. J. F. Filmer, as a result of whose kindness I was enabled to see such a large number of properties in a limited period. I am also deeply indebted to many farmers and pastoralists who made available their own sheep for examination, and also arranged gatherings of other pastoralists, with whom their problems were discussed. I am grateful also to the Acting-Chairman of the local State Committee of the Council for Scientific and Industrial Research, Professor Wilsmore, and to the Secretary, Mr. L. W. Phillips, for the arrangements made on my behalf, whereby I was able to address and meet a considerable number of interested persons in Perth and elsewhere.

# The Bdellid Mite *Biscirus lapidarius* Kramer, Predatory on the Lucerne Flea *Sminthurus viridis* L. in Western Australia.

## A Report on a Visit to Western Australia in July and August, 1933.*

*By G. A. Currie, B.Sc., B.Agr.Sc.*†

*Summary.*

1. A survey of some of the agricultural areas of Western Australia was made to ascertain the status of the Bdellid mite *Biscirus lapidarius* (previously discovered by Womersley) as a control of the lucerne flea *Sminthurus viridis*.
2. Evidence was found in support of the claim that in certain cases the mite does control the lucerne flea.
3. A method of collecting mites in large numbers was devised, and a technique developed for transporting them alive over great distances.
4. Over 13,600 mites were collected and sent as experimental colonies to various points in Western Australia, South Australia, Victoria, and Tasmania.
5. Some statistical data showing the effect of the mite attack on the numbers of fleas were obtained, and are represented graphically.
6. The problem of whether the mite is an indigenous or an introduced species is considered.
7. The type of control exercised by the mite is discussed.
8. Suggestions are made for the direction of future work.

## 1. Introduction.

In 1931, Womersley discovered a predatory mite attacking the lucerne flea in Western Australia, and later embodied his findings in a report‡ published in 1933. This gave a favorable impression of the possibilities of the mite as a factor capable of controlling the flea under certain conditions. Following on this report, the writer was detailed to visit Western Australia for the months of July and August, 1933, to—

(i) assess the value of the mite, as a control for the lucerne flea—keeping Womersley's report in mind;

(ii) gain such further information about the mite as limited time permitted;

(iii) devise means of collecting the mites in numbers sufficient for introduction into new areas;

(iv) devise a technique for sending mites alive over long distances;

(v) send consignment of mites to eastern States where fleas were known as pests and mites were absent: i.e., South Australia, Victoria, and Tasmania; and

(vi) co-operate with the Government Entomologist, Western Australia, in sending consignments of mites within the State, to farmers who might apply for them.

It was arranged that the first trial consignments be sent to Mr. Womersley, in South Australia, to make sure that the species of mite was correctly identified, and to try out methods of packing.

* Since this Report was prepared, mites of the species *Biscirus lapidarius* have been recovered in fair numbers in South Australia and in Victoria at points where Western Australian consignments had previously been liberated. It is obvious that the mites have been breeding freely in the new localities for they were found in all stages of growth.

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‡ *J. Coun. Sci. Ind. Res.* (Aust.) **6**: 82, 1933.

The work was done in collaboration with Mr. L. J. Newman, Government Entomologist, Western Australia, who accompanied the writer whenever his other duties would allow. The Western Australian Department of Agriculture made available accommodation and equipment, and all its officers gave valuable assistance when it was in their power to do so.

## 2. First Survey.

The areas mentioned in Womersley's report were first surveyed rapidly, to ascertain if progress had been maintained in the spread of the mite since the preceding year.

In 1932, at Guildford, near Perth, 50 mites had been placed in a flea-infested pasture where mites had not previously been found. At this spot fleas were very scarce, and a few mites were present in July, 1933.

In an insectary paddock, near the Department of Agriculture, Perth, "about a dozen mites" had been placed out two years previously, where springtails of the genus *Katianna* (near relatives of the lucerne flea) were then common. Here, mites could be found fairly readily under pieces of bark, but scarcely a flea was found.

In Bailey Bros.' property at Denmark, near Albany, mites were found fairly commonly under pieces of bark in flea-infested paddocks. Fleas were not abundant, and the mites had progressed about 100 yards from the line which they had reached the previous winter. On the Denmark State Farm, fleas were abundant; mites could not be found.

On the property at Waroona, where the mite was originally discovered in May, 1931, the line of mites had progressed about a quarter of a mile in the two years. Fleas were scarce, except in one corner, and the mites were to be found all through the fields. In the corner where fleas were common and were causing some damage to the subterranean clover, the line along which mites were more numerous was advancing. During the two months of observation, they progressed throughout the corner, and reduced the flea population to negligible proportions. (Statistical evidence in support of this will be given later in this report.)

## 3. Method of Transport over Long Distances.

This first survey of the areas previously under observation showed that the mite was still acting as an agent partially controlling the flea. In order to try out methods of packing and transport which could be used to get mites alive into the eastern States, trial consignments were sent to Mr. Womersley in Adelaide. Transport over long distances had not previously been attempted.

The mites are small, the adults having an over-all length of about 1.5 millimetre, and a width of about 0.75 millimetre. They are soft-bodied and delicate, are accustomed to a moist atmosphere close to the ground, and are very voracious when temperatures are over 55° F. It was found, in the laboratory, that mites died off within one or two days in dry dishes without food. If moisture condensed on the walls of their container, they got stuck and succumbed rapidly. In the refrigerator —at about 40° F. to 50° F.—they lived for about a week, and did not feed. When removed from the refrigerator, and warmed up to about 60° F., they immediately became active and fed voraciously on springtails supplied. It was clear, therefore, that if they were to be warmed

up at all during the journey, they should be transported under moist, but not wet, conditions, with food supplied, and with reasonable ventilation provided; and that they should be sent during the cooler months of the year.

With these considerations in view, the first consignment was prepared for despatch during the first week in July, as follows:—

A strong glass tube, open at either end, was plugged at one end with dry sphagnum moss wrapped in cellophane. Thin strips of dry bark and dead leaves were then packed loosely in the tube, into which were put (i) lucerne fleas to serve as food for the mites, (ii) a few leaves of clover as food for the fleas, and (iii) the Bdellid mites. The other end of the tube was loosely plugged with moist sphagnum moss wrapped in cellophane, the whole being then wrapped up for postage. The cellophane allows the free passage of moisture without condensation, the loose plugs at either end provide sufficient ventilation, the moist sphagnum ensures a high relative humidity, while the plug of dry sphagnum at the other end of the tube is intended to keep humidity below the point of condensation.

On the Trans-continental train, parcels may be subjected to fairly high temperatures during the day, while later in the journey east, comparatively low temperatures may be experienced. Consequently, provision had to be made for these varying conditions. Trial consignments sent both by air mail and by mail train reached their destinations in good condition. No great change was made in the technique of later consignments. The green leaves put into the trial consignments were later found to be unnecessary, as fleas could easily survive for a week or longer without food, and they also caused the parcel to become too moist, so they were not again included.

In order to avoid the possibility of sending undesired insects in the parcels, all the mites and fleas collected in the field were again gone over individually in the laboratory before being packed. All material to be included with the consignments was carefully searched for eggs or insects before despatch.

Air mail, where available, proved to be a particularly good mode of transport, owing both to its saving of time and to the low temperature at which the parcels were carried.

Experimental consignments of mites were successfully delivered in South Australia, Victoria, and Tasmania, to State authorities who had previously requested supplies.

### 4. Collecting Mites in the Field.

The development of a technique for the rapid collection of mites in the field and the discovery of a new area where they were present in large numbers made their breeding in captivity unnecessary. In any case, the latter project would be fraught with difficulties.

Previous to this period, the total number of mites collected for experimental purposes had been about 450, so it is clear that collection on a large scale was a new development.

Aspirators in common use for the collection of small insects were employed to suck up the mites from the under-side of pieces of bark, fence posts, or fallen branches to which they clung. Respite from this continuous sucking up mites with the mouth—which made the throat

very raw—was gained by using the bulb and valves of a two-way enema syringe to give the necessary sucking current. The bulb was attached to the end of the tube of the aspirator, and a continuous current maintained by hand pressure on the bulb.

The rate of collecting varied with the number of mites present and with the availability of debris from which they could be collected. One mite per minute was an average rate where supplies were not heavy. At Burekup, between heavy showers of rain, when collecting from the under-sides of boards which had been placed out to act as "traps," Mr. Offer and the author each collected 2,000 mites in two hours. This record was due to the heavy population of mites, the trap boards placed out by Mr. Offer to aid collection, the heavy rain which had driven the mites to shelter, and the strenuous and continuous collecting made necessary by the imminence of more rain.

Mites were collected into glass tubes containing dry leaves and numbers of half-grown fleas to serve as food during transit. These fleas were greedily devoured in the tubes.

Collection, at first, was from branches and other debris present by chance in the fields, but later, boards were laid out in an area where mites were plentiful, and large numbers were then readily collected in a short time.

To supply large numbers of mites with sufficient "fleas" for food, without overcrowding, was quite a problem, so, while mites were being stored at the laboratory before despatch, they were held in cold store. Under these conditions, they did not require food and did not seem to suffer any inconvenience, as they fed readily on being warmed up, laid eggs *en route* for the eastern States, and in most cases arrived alive at their destination.

## 5. Collections made and Consignments dispatched.

Throughout the period of two months, collection of mites were made, coincident with other activities. With the assistance of Mr. Newman, Mr. Offer, and others, some 14,750 mites were collected.

There were considerable numbers of casualties before despatch, and the final consignments were:—

| | Mites. |
|---|---|
| (1) Within Western Australia, consignments of about 100 mites were sent to persons who had applied to the Department of Agriculture; 47 consignments were despatched with a total of .. .. | 5,050 |
| (2) To South Australia, 6 consignments with a total of | 2,910 |
| (3) To Victoria, 5 consignments with a total of .. | 3,220 |
| (4) To Tasmania, 4 consignments with a total of .. | 2,420 |
| Total .. .. .. | 13,600 |

As was to be expected, mites arrived in better condition in South Australia and Victoria than in the more distant Tasmania, but even the last-named State received in the vicinity of 300 live mites from the consignments.

In Victoria, approximately 90 per cent. were stated to have arrived alive. In all cases feeding was started immediately after liberation.

It is well at this point to stress the fact that all consignments sent to other States during the period under review were in the nature of experiments, designed to see whether mites could be successfully introduced into new areas, whether they could multiply there, and whether they would then act as controlling agents for the lucerne flea. Work on a larger scale would have to follow indications from these experiments.

## 6. Conditions at Mr. Weller's Farm, Waroona.

The special interest of this property lies in the fact that the mite was first discovered there. Mr. Weller had remarked to Mr. Womersley that in areas where fleas had been common the year before (1930) they were then (May, 1931) scarce. Womersley then made an investigation, and found the mite (which he later identified as *Biscirus lapidarius*) to be present in considerable numbers. He also made observations over the two winters 1931 and 1932 before leaving to take up duty at the Adelaide Museum. Apparently, the mites entered the property at the north-east corner, had travelled across diagonally, and on the writer's advent in July, 1933, had just reached the extreme south-west corner of the property. (See Fig. 1.)

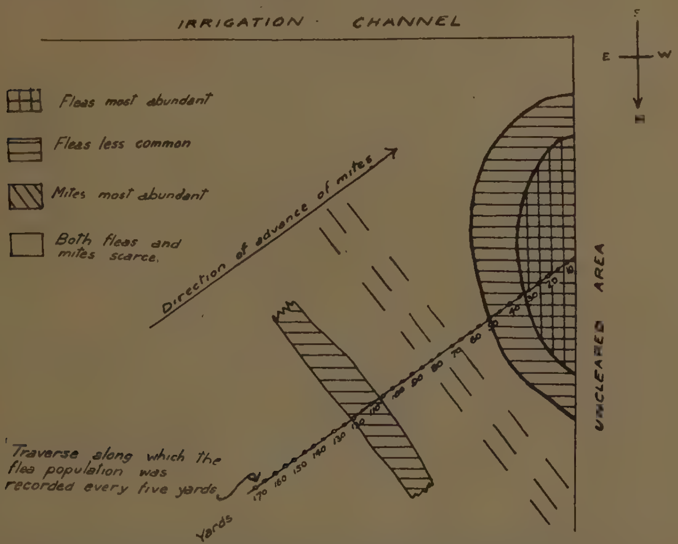


FIG. 1.—Weller's Field, Waroona, W.A., July, 1933. Sketch showing general distribution of mite and flea population, and position of line of traverse. *Note.*—Fleas and mites were present all through the area (see Fig. 2), but were most numerous at places indicated.

On the writer's first visit to Waroona, only general observations were made, but on three subsequent visits some statistics were collected with a view to giving a picture of the progress of the mite in controlling the flea population.

At one corner of the field in which the mite had been operating, there was still a patch infested with fleas to a sufficient degree to cause some economic damage. Mites were found in large numbers at the

edge of this area, but no exact estimate of the mite population could be made. Mites collect under sticks, and so give an uneven distribution in any area. One could only generalize, and say that the mite population was large or small. In the case of the fleas, an estimate which gave a comparatively accurate idea of their numbers could readily be made. The subterranean clover on which they lived during this period was very short; and by placing a glass cylinder quickly down over an area, before the fleas could jump away, the numbers could readily be counted through the glass. While this method did not give the exact numbers per unit area, it gave numbers which were sufficiently accurate for all practical purposes of comparison.

A traverse from a point in the fence was marked out through the paddock, along a line pre-determined. An estimate of flea numbers was then made at uniform distances of 5 yards, on 27th July, 11th August, and 28th August.

The following diagram (Fig. 2) shows the result of these estimates and shows the correlation between flea and mite populations. The flea diagrams are compiled from numerical values accurately determined; the mite diagram represents the actual position, but is made on the basis of careful observation only.

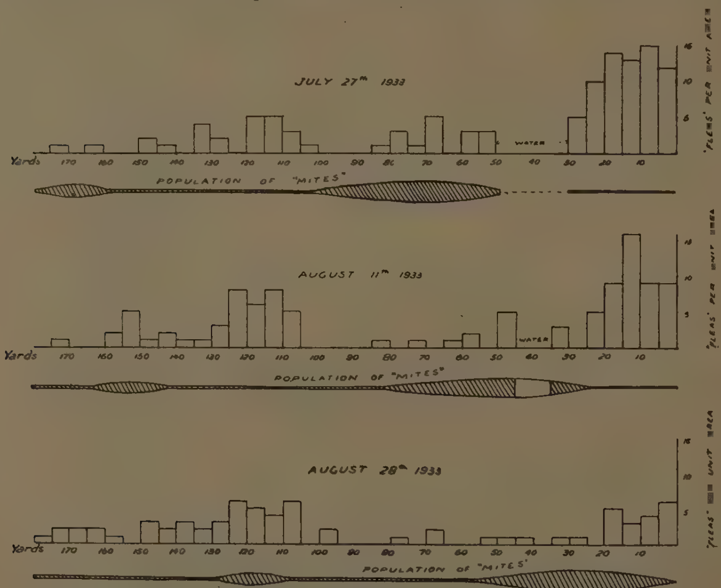


FIG. 2.—Traverse through Weller's Field, Waroona, W.A., showing the decrease in "flea" population at the different dates with the advance of the mite.

"Flea" = *Sminthurus viridis*. "Mite" = *Biscirus lapidarius*.

The field was quite flat, and throughout its area the sandy soil did not appear to vary in texture or vegetative cover.

The way in which the mites had reduced the flea populations is sufficiently striking to require no elaboration. It may be mentioned here that in front of the line of mites the fleas were represented

predominantly by the younger instars—while behind the line of mites those fleas which remained were predominantly the later instars, as the mites feed mostly on the half-grown, or smaller, fleas.

### 7. Conditions on Mr. Torr's Property, Waroona.

A field considerably infested with lucerne fleas was discovered on this property. Damage to subterranean clover was apparent across the entire field, to a line within 50 yards of the fence; from this line to the fence damage was less obvious, and fleas were visibly less common. Examination of some dried maize stalks lying around disclosed Bdellid mites in this latter region, but none could be found in the former. Fig. 3 represents the difference in flea population between the two areas. No change in soil type was apparent along the line mentioned.

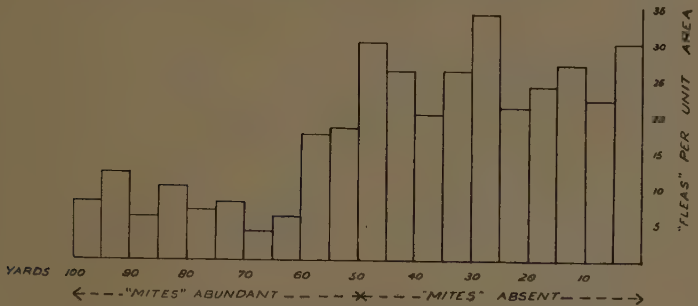


FIG. 3.—Diagram showing the sudden decrease in numbers of lucerne fleas at the line where mites were actively attacking. Torr's paddock, Waroona, August, 1933.

"Flea" = *Sminthurus viridis*. "Mite" = *Biscirus lapidarius*.

### 8. General Survey.

Surveys of a somewhat limited nature were carried out, as opportunity offered, in three areas, as follows:—

(i) The coastal plain from Bunbury to Perth.

(ii) The Muresk area, on the Great Southern Line.

(iv) The Denmark area—west from Albany.

(i) *Perth to Bunbury.*

Mites were to be found in Armadale, Cannington, and other suburbs of Perth; and, generally speaking, they were distributed throughout the agricultural areas all the way to Bunbury. A small field at Waterloo was badly infested with lucerne flea, but a traverse across it disclosed the presence of the predatory mite in one corner. It appeared that the mites had come from rough ground at the edge of the field; any piece of stick lying on the ground in that area sheltered a number of mites. The subterranean clover was more damaged in the area where the mite was not present than in the area where it was found.

Mites were found plentifully in the Burekup area, along the edges of a field on Mr. Hurst's property, while in the centre of the field fleas were very common and mites were absent. In fields adjoining,

fleas were scarce all over, and mites were present, but not numerous. Only in places where fleas were fairly numerous were large numbers of mites ever found, as, naturally, they could develop to large numbers only when a plentiful supply of food was available.

Both fleas and mites were fairly scarce on Mr. Offer's property, except on one patch of about 2 acres, where fleas were common; here it was found that mites were numerous and could be picked up readily from the under-side of pieces of timber lying on the ground.

On Mr. Crampton's property, Burekup, mites had been recorded, two years before, apparently advancing from a roadway in a southerly direction. At the time of the writer's advent, fleas were scarce in the two fields nearer the roadway, but were common in the field remote from the roadway. Here, in one spot, mites were becoming numerous, spreading from a centre under some shrubs in the field of clover.

The survey included numerous other properties, and in most cases mites could be found after a more or less prolonged search.

In one particular case, at Wokelup, fleas were found to be abundant in two large fields adjoining the roadway; in one count as many as 25 fleas per square inch were found. No mites could be found throughout this field, but prolonged search revealed a few under sticks at the roadside. It would require close observation over a number of years to ascertain the reason for this apparent anomaly.

It appears reasonable to state that mites were present throughout the Perth to Bunbury area, in scattered locations.

(ii) *The Muresk Area.*

Here, experience was limited to the property of Mr. Burges, Burges Siding, and to the land held by the Muresk Agricultural College. By courtesy of Mr. Burges (owner of the first-named property), Mr. Newman and the writer were able to go over a large area of subterranean clover land, where it was found that fleas were uncommon and that mites were present throughout the area.

The Principal of Muresk Agricultural College made it possible to to survey most of the lands of the College; it was found that mites were present all through the area. A small number had been released in one field the previous year, but they were found to be present so far away from the point of liberation that it could only be concluded that they had been present for a number of years.

(iii) *The Denmark Area.*

The mites—originally found on the property of Bailey Bros. in 1931 —were found to have spread on that property since last season. Progress for one year had been slow, amounting only to about 100 yards in one place. No mites were found on farms a few miles from this place, nor could they be found on the State Farm at Denmark, where a small colony had been liberated the previous season by Mr. Womersley.

Fields of clover which were heavily infested with fleas were searched for mites without success.

This area appears to be less effectively colonized by the Bdellid mite than the other areas mentioned previously. The only places where the mites were found were those recorded by Womersley in his previous report.

## 9. Experiments.

Few opportunities for laboratory experiments presented themselves in the short time devoted to this work. A few experiments, however, were set out, and notes made as follows:—

(*a*) *In the Laboratory.*

(i) Mites when supplied with food at ordinary winter temperature in Perth (about 65° F.) lived for about nine days.

(ii) They could be held alive in the refrigerator for about a week to twelve days without feeding.

(iii) Mites were observed to feed on a few small Collembola other than *Sminthurus.* Womersley also found that they could live on Psocids.

(iv) It was desired to ascertain if mites would attack the eggs of *Sminthurus viridis.* Eggs were obtained by keeping *Sminthurus* in petri dishes on leaves of *Cryptostemma.* Mites were then placed in the dishes with these. At first, the mites were seen to react in some measure to the presence of the eggs, running excitedly over them, but no attempt was made to suck them, and the mites died in three days without attempting to feed on them.

(*b*) *In the Field.*

Under this heading should come all the experimental liberations of mites made from consignments sent within Western Australia and to other States. A few small, more detailed experiments, however, were laid out as follows:—

(i) At the State Farm, Denmark, 200 mites were placed in a marked position in heavily flea-infested clover and put for observation in charge of officers of the Department of Agriculture.

(ii) In a small isolated patch of flea-infested Cape weed on the Esplanade, Perth, 50 mites were placed on 22nd July. On examination on 26th August, some small mites, presumably the progeny of those recently liberated were found.

(iii) Near York, 100 mites were placed on lucerne with a few pieces of bark to shelter under, on 22nd July. On 2nd August, examination revealed four mites under the pieces of bark, one obviously just moulted.

(iv) At Muresk Agricultural College, two small lots of mites—one of 30 and the other of 70—were placed close to "soaks" in the fields where fleas were fairly common.
Observations are to be made by the College staff, to ascertain whether the small colonies increase, and how long the mites remained active, through the spring and summer months, in such moist surroundings.

(v) Arrangements were made with State authorities for observations to be made from time to time on the experimental colonies sent to South Australia, Victoria, and Tasmania.

## 10. Discussion.

This section can be considered under three headings:—

(i) History of mite in Western Australia.

(ii) Observations in the field.

(iii) Occurrence of mites and fleas.

(i) *History of Mite in Western Australia.*

As noted by Womersley, the first man to notice that an agent was at work controlling the lucerne flea was a practical farmer, Mr. Weller, of Waroona. This in itself speaks well for the intensity of the control operating. It was at this place, Waroona, that Womersley discovered that the Bdellid mite was the controlling agent.

The present survey showed that the mite is distributed all through the Perth to Bunbury coastal plain, through the York-Northam agricultural areas, and in parts of the Denmark district.

Such a widespread occurrence suggests an introduction of long standing; its limited distribution in the Denmark area supports rather the hypothesis of introduction from an outside country than that of its being an indigenous species.

Mr. Offer of Burekup was of the opinion that the flea population had been declining in that district over a period of about seven years. During the last three years, its ravages had been negligible. The mite is thoroughly established there, and it appears to be reasonable to correlate the waning of the flea population with the spread of the mite.

The predatory mite *Biscirus lapidarius* has not so far been found in any State of the Commonwealth other than Western Australia.* If experience with the introductions recently made into the eastern States proves that the mite can live there, then its former absence will give support to the theory that it is an introduced species in Australia. This does not entirely eliminate the possibility that the mite may be indigenous. The mites represent a very ancient family, and the fact that they had not been discovered previous to 1931 is not evidence that they were not present. It was with the widespread cultivation of subterranean clover in Western Australia, a development of fairly recent origin, that the lucerne flea became a pest of major importance. It is quite likely that a predator with such slow spreading powers would lag years behind its prey before getting thoroughly established in new districts being opened up by laying down pastures of subterranean clover.

Further evidence will be required to prove or disprove either of the conflicting theories.

(ii) *Observations in the Field.*

In the field, mites were never found feeding on any prey other than lucerne fleas. Their preference was for fleas rather less than half grown, but, when hungry and when smaller fleas were not available, they would attack full-grown specimens.

In all cases observed by the writer, the colonization of any particular area for that year by mites, originated at, or near, trees in fields or by the roadside, or rough ground covered with lying timber or other debris. There was some evidence to suggest that the mites could better survive the summer where some extra shade or moisture existed.

There was observed, too, a distinct preference for certain pieces of timber as shelter. In the same place on five successive visits, one piece of pine yielded over 50 mites per visit, while larger pieces of wood were much less productive. The largest individual catch of mites for a single piece of timber was 184 collected at Burkeup from a fallen limb about 7 feet long and 3 inches through.

* Late in 1933, after the foregoing had been written, a mite predatory on the lucerne flea was discovered in Tasmania by Mr. N. A. Morris, an officer of the Tasmanian Department of Agriculture. Mr. A. L. Tonnoir, of the Division of Economic Entomology, who was then on a visit to Tasmania, identified the mite as *Biscirus lapidarius*. This mite was found at a point where no mites from Western Australia had been liberated.

Mites congregated under logs more readily if the weather were cold or wet, so could most readily be collected under these conditions. Fleas also had the habit of sheltering in the same situations in wet weather. When traversing an area examining the pieces of fallen timber, there was a very noticeable difference between the numbers of fleas present on the timber when no mites were present, and pieces a few yards distant where mites had taken heavy toll.

The greatest population of fleas was found in an area from which mites were absent; the stupendous total of 3,000 fleas in a square foot was counted in that area. In no case where mites were operating was there anything like this infestation. The very fact that areas do still exist in Western Australia where the flea is still a serious pest is an indication that the control exercised by the mite is of a particular type, the character of which is discussed later in this paper.

An interesting state of affairs existed in a vegetable garden in one of the suburbs of Perth. For three seasons at least the mite has been present; the flea had been known in the area for many years. Fleas are present during the greater part of the year owing to the continuous irrigation. During the three years, fleas have been present in fair numbers, though not enough to cause economic damage, and mites have also been present. Possibly, here we have an example of the state of balance that would be reached if both mite and flea were operating continuously under favorable conditions over a long period in the same area.

(iii) *Occurrence of Mites and Fleas.*

In considering the type of control exercised by the mite, the following points, based on field observations can be tabulated:—

(i) Where fleas were particularly abundant over large areas, mites were absent.

(ii) In general, when mites and fleas were both present over large areas, both were rather scarce.

(iii) Where mites occurred in one portion only of a flea-infested area, fleas were abundant in the mite-free portion, fleas and mites were not numerous in the remaining portion, but both were numerous along a front dividing the two portions.

(iv) A traverse across such a "front" showed a progressive drive of the mites in the direction of the previously mite-free area. The greatest concentration of mites was to be found just behind the "front," and it was also observed that most of the fleas found in the area occupied by mites were large ones.

(v) At Waroona, the area occupied by the mites has been observed to extend steadily, over a period of three seasons, fleas being scarce within the area and common outside it.

(vi) Small areas in which both fleas and mites were common occurred in localities in which both fleas and mites were scarce elsewhere.

(vii) The occurrence of the mites suggested that they survived the dry season in sheltered places under debris and trees, where cover and shade were available.

Statements (i) to (v) strongly suggest that the mites control the fleas at a low density, for, though any one of these facts might be due

to the effect of the physical environment, it would be a remarkable coincidence if the physical environment produced all of the effects observed. On the other hand, an efficient natural enemy would be expected to produce precisely these effects.

Statement (vi) may be associated with (vii) (i.e., be the result of an irregular pattern of the physical environment) or it may be the result of the interaction of a specific natural enemy and its prey.

Nicholson* contends that a probable end result of the interaction of a specific host and parasite is the scattering of hosts in widely separated groups, which first grow rapidly in size, are then found by parasites and diminish rapidly, and finally disappear—while new, small groups appear in other places, and follow the same course.

The state of affairs found at Burekup was very suggestive as an illustration of this form of control.

Statement (iv) showed that the greatest density of mites occurred a little behind the front of attack. This condition of affairs, as illustrated in the field at Waroona, is consistent with the inter-specific oscillations described by Nicholson as a result of purely theoretical considerations. To obtain the whole story, it would be necessary to obtain statistical evidence over a period of years.

## 11. Recommendations.

Further study is required with the following aims in view:—

To ascertain the modes and places of survival of the mites through the summer period.

To correlate the rate of growth in each stage of mite development with conditions of temperature and humidity.

To correlate mite activity with those conditions.

To compare the reaction of the mite to physical conditions with the reaction of the flea to those conditions.

On the evidence obtained after investigating the foregoing, to determine whether artificial means could be used to ensure survival of the mites in certain localities. (For instance, by providing heaps of debris for shelter.)

To determine the best conditions under which mites can be established in new areas, and as a corollary, the number and condition of mites necessary for establishing colonies in new areas.

## 12. Acknowledgments.

The writer is much indebted to Mr. G. L. Sutton, Director, Western Australian Department of Agriculture, and the many officers of that Department who readily gave assistance when possible, but particularly to Mr. L. J. Newman, the Government Entomologist, who co-operated whole heartedly in all phases of the work. He thanks also particularly Mr. Offer, of Burekup, whose help was invaluable, and Mr. Womersley, Entomologist at the Museum, Adelaide, whose zeal in co-operation was unflagging.

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* "The balance of animal populations" *J Animal Ecology*, **11**: **161, 1933.**

# Pregnancy Paralysis of Ewes. Feeding Experiments in Relation to the Disease.

*By D. T. Oxer, B.V.Sc.**

The observations described in the brief article that follows were made by Mr. Oxer when he was an officer of the Tasmanian Department of Agriculture, and when he was assisting with a programme of research carried out by the Council under the Empire Marketing Board—Australian Pastoral Research Trust Scheme (see this Journal 4 : 133, 1931). It will be seen from the article that the work is far from complete, and that much further light remains to be shed on the cause of the disease as a preliminary to the development of methods for its control. It is hoped to arrange that the work will be continued in Victoria during the coming year.—Ed.

## 1. Introduction.

The disease is known in veterinary literature under many names, such as "lambing paralysis," "pregnancy disease," "acidosis," "pregnancy toxaemia," but more commonly in Australia as "twin disease." As is now commonly recognized, the disease may affect ewes which carry a single lamb, as well as twin lambs or triplets. "Pregnancy paralysis" is, therefore, a popular name which more suitably describes the condition.

Sufficient data are available to preclude either bacteria or parasites as causal agents, the disease appearing rather to be one of deranged metabolism—probably of dietetic origin. It is yet another example of a disease which has become more common with heavier stocking of pastures.

As the result of the observations, not only of stock-owners but also of veterinarians, numerous theories have arisen as to the cause of the condition, and many different treatments and preventive measures have been more or less unsuccessfully attempted. Gilruth(1, 2), who, many years ago, closely observed the disease, was of the opinion that obesity and plethora were immediately responsible, and advised exercise in the later stages of pregnancy, together with daily depasturing on green nutritious grasses, as a means of prevention. A similar opinion is held by others who have made investigations. Rose(3) has given some striking examples of very severe and widespread mortality in poor and store pregnant ewes during drought periods in New South Wales, where the symptoms were indistinguishable from those seen in fat ewes. In these instances, the ewes were being fed on concentrates in the form of linseed nuts, which were given at regular intervals at the same part of the run, this resulting in the ewes never moving from the source of supply. The disease was successfully combated by driving the vehicle containing the nuts through the runs and ensuring that, by dropping the nuts during its progression, the flock obtained enforced exercise.

Dayus and Weighton(4) are among those who consider that a sudden shortage of food at a critical period of gestation is responsible

* Now Veterinary Officer, Commonwealth Serum Laboratories.

for the onset of symptoms. Hopkirk(5) advised a rising, rather than a falling, condition of the ewes from mating to lambing, and flushing on lush feed at the danger period.

Leslie(6), as the result of field investigations and feeding experiments, concluded that increasing the food supply towards lambing was the important factor, and that exercise without this increased supply was of no value in prevention.

In short, we may, without fully reviewing the literature, summarize the theories which have been advanced as—(*a*) lack of exercise; (*b*) extreme adiposity and plethora; (*c*) a check in the feeding of ewes at a certain time (usually understood to be about six weeks) prior to lambing; (*d*) a gradual fall in body condition from the time of mating to that of lambing; and (*e*) mineral imbalance or deficiency.

It is rather a significant fact that the incidence of the disease is not greater in stud animals, which are continuously maintained in a high body condition with the aid of supplementary rations, and the conviction grows on one who has had field experience that the disease should not occur in well-managed flocks.

If the predisposing causes could be defined so that suitable preventive measures could be recommended at the right time, the control of the disease would obviously be rendered more simple, and it was with the object of so doing that experiments based on the above theories were undertaken. Such a series of experiments should be carried out under carefully controlled pasture conditions, and using considerably larger groups than were used in the present instance. The expense of such work would, however, be very considerable, and as, apart from this, the pastures required were not available, it was decided to carry out a small series of experiments under artificial feeding conditions.

For this purpose, a sufficient number of small paddocks of approximately 1 acre in area were fenced off, each being furnished with a self-feeder and water trough. The concentration of sheep in each area was sufficiently great to allow of no food being taken, with the exception of the very small amount of grass available under such conditions, other than that supplied in the self-feeders. The rations were placed in the feeders at regular intervals, both morning and evening.

## 2. Feeding Trials Carried out in 1931.

For the trials carried out in the year 1931, 106 full-mouth Corriedale ewes which had been "flushed" on green feed prior to mating were finally selected. The mating had been carried out under supervision, whereby with a suitable system of marking the date of mating of each ewe was known. The ewes were then divided into five equal groups in such a way that all members of a group should lamb as nearly as possible about the same date.

The objects of the experiments were—(*a*) to maintain one group as a control in an even body condition; (*b*) to increase the condition of two groups; and (*c*) to administer a check to two further groups in which the body condition had been maintained at a constant level. No method of gauging the condition of the animals was available other than that of visual observation and manual examination.

The rations consisted mainly of a chaff mixture containing three parts of oaten to two parts of lucerne chaff, each being of the best quality procurable. The standard quantity of chaff mixture given was 3 lb. per sheep per day, determined by allowing one group as much as they required for a period of one week and then estimating the daily requirements of each sheep. This quantity was varied from time to time if considered necessary. The experimental scheme is summarized in Table I.

TABLE I.

| Group. | Object. | Rations (per sheep per day). |
|---|---|---|
| A | Maintenance of condition .. | Standard quantity of chaff |
| B | Increasing condition .. | Chaff mixture *ad libitum* |
| C | " " .. | Standard quantity of chaff plus 4-oz. glucose (maize syrup) and 4–6 oz. linseed meal or nuts |
| D | Check in nutrition .. | Standard quantity of chaff |
| E | " " .. | " " " |

No group was at any time forced to take exercise. Six weeks before the due date of lambing, the rations of Group D were reduced by one-quarter for one week, and by a further quarter for the following week, after which the sheep were replaced on the usual rations. The rations of Group E were reduced for one week, also six weeks before lambing, by one-half.

(i) *Experimental Field Stations.*

Work was commenced on three private properties, but only that carried out on one will be described, as on the other two it was, for various reasons, unsatisfactory. On this property, 35 five-year old Leicester-cross ewes were available. The ewes, which were almost in prime condition, were mated under supervision to Southdown rams. The high body condition of the animals was maintained throughout the period of gestation until six weeks before lambing, when they were divided into two groups of 19 and 16 respectively. The smaller group was left on pasture as a control, while the larger was checked by placing for one fortnight in a $\frac{1}{2}$-acre paddock containing but a moderate amount of grass. The food became so scarce that the ewes were allowed to graze over a second almost equally small paddock for half an hour per day during the second week.

At the end of the fortnight's check the ewes were extremely hungry and very hollow, having obviously been markedly reduced in condition. No case of the disease occurred in either group, although a large percentage of twins were subsequently born.

(ii) *Results of* 1931 *Trials.*

As far as could be judged by ordinary methods of examination, the condition of the ewes in Groups D and E was maintained, up to the time of reduction in rations, by the rations provided. Groups B and C, but especially the latter, put on considerably more weight on account of the extra food eaten.

The sudden reduction of rations for Groups D and E undoubtedly caused a very noticeable drop in their body condition. No cases of the disease, however, appeared. A short time before their due lambing date, five cases of prolapse of the vagina occurred, although no group was particularly affected. Treatment in almost every instance was carried out as soon as the condition occurred; it consisted of emptying the bladder by pressure, disinfecting, massaging, and then replacing the parts, inserting a cotton wool plug, stitching the labia of the vagina, and placing the ewe in a narrow pen with a sloping floor. It is probable that the plugging and stitching were not necessary. The condition occurred, as far as it was possible to judge, very near the end of pregnancy. Two of the ewes died notwithstanding treatment.

We have no reason to doubt that the cause of the prolapse was that suggested by Gilruth(1), namely, that the distension of the urinary bladder which follows prolonged decubitus is immediately responsible for the eversion, the gravid uterus forcing the bladder backward towards the vulva. A general lack of tone through too little exercise renders the condition more liable to occur.

### 3. Feeding Trials Carried out in 1932.

For the experiments carried out in the year 1932, 120 six-tooth and full-mouth Romney-Southdown and Romney-Marsh ewes were made available by a Tasmanian pastoralist. These were of a type likely to produce a large percentage of twin lambs, and, at the time of selection, were in a fat condition.

The experimental treatment of the ewes was determined by the following theories, namely, that the disease was due to—(*a*) a plethoric or high body condition during the period of gestation; (*b*) a gradually declining condition from mating to lambing; (*c*) a sudden check at the critical period before lambing; or (*d*) lack of exercise. The experimental treatment may be summarized as follows:—

| | |
|---|---|
| Group A—Gradually rising condition till lambing | Enforced exercise. |
| „ B „ falling „ „ „ | |
| „ C „ rising „ „ „ With a severe check to consist of a reduction in rations to $\frac{1}{2}$ lb. chaff per sheep per day for one week at a period six weeks before lambing. | |
| „ D—Similar to A, but no exercise. | |

This programme entailed some repetition of the previous year's work, but this was thought advisable on account of the different class of sheep used. For the purpose of more accurately assessing the gains or losses made by each group, the ewes were weighed, as far as possible consistent with weather conditions, every fortnight. The time of day at which weighing took place was always the same, and the ewes were always weighed when dry.

(i) *Flushing and Mating.*

The process of "flushing," the object of which is to stimulate ovarian function, consists of subjecting the ewes to a short period on low rations, followed by ten days' to one fortnight's feeding on rich food, after which mating is commenced. The ultimate object of the

process is, of course, to increase the lambing percentage. Marshall and Potts(7) have demonstrated that such a procedure causes very marked increases in the number of lambs born. Of the various rations which they successfully tried, one was oat grain given at the rate of $\frac{1}{2}$ to $\frac{3}{4}$ lb. per sheep per day. These authors state that the gain in weight during the ten days on extra feed should be at least 7 lb. per ewe.

Following this practice, the ewes, after arrival at the experimental station, were given a very low chaff ration ($\frac{1}{2}$ lb. per ewe per day) for several days, and were then given for one fortnight 3 lb. of chaff mixture together with $\frac{3}{4}$ lb. oat grain per sheep per day. There was a marked response, as shown by the increase in weight in the majority of the ewes. Many increased more than 10 lb. in weight, although there were some which actually lost weight during this period, probably due to a lack of appetite for the new rations. Mating was commenced at the end of the flushing period, and, as in the previous year, was carried out under supervision. Notwithstanding the flushing procedure, the lambing percentage finally obtained showed no increase over that obtained in the parent flock under normal pasture conditions. On the completion of mating, which was allowed to continue over two oestral periods, the ewes were divided into four equal groups, each consisting of animals which had been mated as nearly as possible at the same time.

(ii) *Rations Provided.*

As in 1931, the rations consisted mainly of high-quality oaten and lucerne chaff, mixed in the proportion of three to two. Groups A, C, and D received an extra supplement of 2 oz. oat grain and 3 to 4 oz. of bran per sheep per day. The principle adopted was to allow the ewes as much as they could eat without waste. The rations of Group B were slightly reduced from time to time. The daily amount eaten by the various groups was found to fluctuate quite considerably, although 4 lb. per sheep was the average daily quantity of chaff eaten.

Coarse salt was made available in boxes. During the last three months of pregnancy, all groups daily received $\frac{1}{2}$ oz. of sterilized bone-flour per sheep. This was mixed throughout the chaff, and, although the ewes at first evinced a marked dislike to it, they soon took the ration quite readily.

(iii) *Response of the Ewes to Experimental Feeding.*

As the experiment proceeded, it was readily seen that quite a large number of ewes in each group were not making the progress hoped for. In order to obtain a more accurate conception of how the groups were responding to treatment, the ewes in each group were classified according to the gain in weight made four months after mating. Those which had gained more than 14 lb. by this date were considered to be making progress, while those that had not done so were considered to be losing weight. The figure taken, namely, 14 lb. was based on data collected at post-mortem examination of ewes in the final stages of pregnancy, where it was found that the weight of the foetus and foetal fluids was generally in the region of 26 to 30 lb.

Fig. 1 graphically illustrates the average weights of the progressive portion, while Fig. 2 represents the average weights of the non-progressive portion of each group.

It can be seen that the required effect was produced in Groups A, C, and D, but not in Group B, where the body weights should have remained at an even level or even declined. Fig. 2 more clearly represents what should have been achieved by the whole of B Group. It can also be seen that the reduction of food caused a very severe check to Group C.

The comparison of the weights of the ewes after lambing with that at the beginning of the experiment is the true indication of the increase in body weight. The final weighing of the ewes was carried out as soon after lambing as possible, usually within eight hours, but sometimes not till sixteen hours after. These comparisons are summarized in Table II.

Table II.

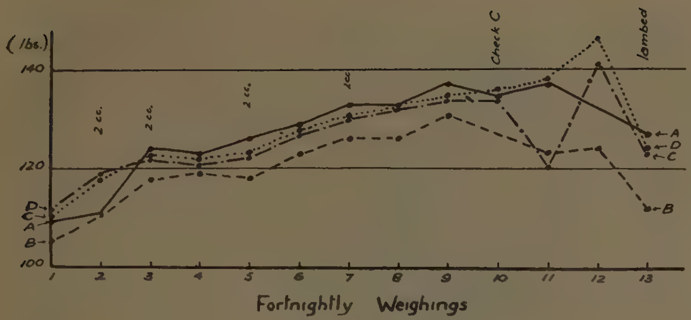
| Group. | Progressive Portion. | Non-progressive Portion. | Original Average Weight. | Final Average Weight. | Average Increase or Decrease. |
|---|---|---|---|---|---|
| | | | lb. | lb. | lb. |
| A | 14 ewes .. .. | .. .. .. | 110 | 127 | + 17 |
| | | 13 ewes .. .. .. | 122 | 114 | − 8 |
| B | 16 ewes .. .. | .. .. .. | 105 | 112 | + 7 |
| | | 9 ewes .. .. | 104 | 100 | − 4 |
| C | 18 ewes .. .. | .. .. .. | 111 | 123 | + 12 |
| | | 6 ewes .. .. | 109 | 98 | − 11 |
| D | 21 ewes .. .. | .. .. .. | 115 | 123 | + 8 |
| | | 6 ewes .. .. | 111 | 98 | − 13 |
| | 4 dry ewes ... | .. .. .. | 112 | 143 | + 31 |
| | | 2 dry ewes .. | 130 | 112 | − 18 |

Not included in the above figures are the weights of four ewes which died, and of two others which were withdrawn during the experiments. For the sake of comparison, the weights of four progressive and two non-progressive ewes which did not conceive (one of each being from Group C, the remainder being more or less evenly distributed through the other groups) are included.

The average increase in weight, especially after deducting about 3 lb. for wool increase, cannot be considered as very great, even in the best of the progressive portions. Several factors, which will be discussed later, may have been responsible for this comparatively low increase in weight.

(iv) *Lambing Percentage Obtained.*

The percentage of lambs obtained was nearly 100, although the percentage reared was only 91.5 per cent. This percentage was approximately the same as occurred in the original flock under normal pastoral conditions. Of the lambs born, there were eight pairs of twins and one set of triplets. All the lambs were weighed within two or three hours of birth, the average weight of single lambs being 10½ lb., the weight of the smallest being 6 lb. and of the largest 14¼ lb. The average weight of individuals of twins was 8¼ lb.



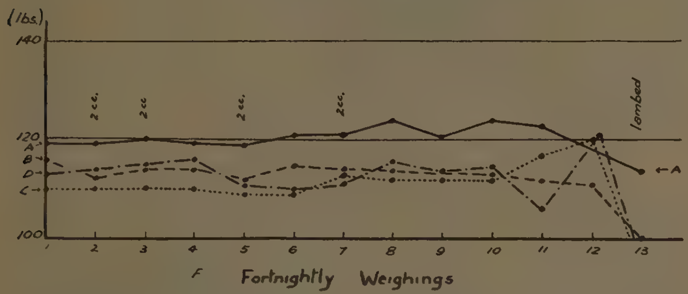




FIG. 1 (*top*).—Progressive portion of each group.
FIG. 2 (*bottom*).—Non-progressive portion of each group. *Note.*—2 cc. = treatment with 2 cc. carbon tetrachloride.

## 4. Discussion of 1931 and 1932 Trials.

The ewes included in the first year's experiments were never in more than good store condition, and for this reason it may be argued that they were not in a sufficiently fat condition to contract the disease. This, however, raises the question as to what animals actually are susceptible. Without entering into a lengthy description, it may be stated here that poor and store ewes have been seen, under field conditions, suffering from a disease of which the symptoms were similar to those of pregnancy paralysis as seen in prime ewes. It is therefore considered that the animals used in these experiments could have contracted the disease under the proper conditions.

The second year's experiments were narrowed down somewhat so as to include fewer factors than in those of the first. They were, however, a repetition, with greater facilities for more extended and detailed observations, and with a type of animal in which the disease is more usually seen.

On reviewing the 1932 experiments, it may be thought—(*a*) that sufficient increase in weight, in those groups where it was required, was not made; and (*b*) that the members of each group should have responded more evenly.

The artificial conditions under which the ewes were kept will largely answer both criticisms. The second objection may be met by the fact that the weaker animals tend to be continually pushed away from the self-feeders, a large share of their food being taken by more robust individuals. It is possible also that the rations provided were not ideal for pregnant animals, although many showed a very considerable increase in weight. Another factor which may be borne in mind is the depressing effect on the appetite of several treatments with carbon tetrachloride, which was used on several occasions to reduce worm infestation. This question, has, however, been fully discussed in a separate paper(8).

Notwithstanding these factors, it is considered that definite negative results have been obtained in so far as a check at a period six weeks before lambing is concerned. Neither under normal pasture, nor under artificial, conditions did cases develop in animals which were of a susceptible type and yet received a very severe check. As regards the other factors operating, it is impossible to conclude whether an adverse or beneficial effect on the occurrence of the disease was obtained, since no cases developed.

## 5. Acknowledgment.

The maintenance and immediate supervision of the experimental animals was carried out with the greatest possible thoroughness by Mr. V. O. Fletcher, retired Stock Inspector, Department of Agriculture, Tasmania. We have to thank the following Tasmanian pastoralists for assistance rendered during the work:—L. K. S. Mackinnon, Esq., Evandale; J. Hawley, Esq., Evandale, for providing the sheep used in the field experiment; and K. Headlam, Esq., Cressy, for providing the sheep used in the 1932 experiments.

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# PLATE 1.

(The Diagnostic Value of the Chlorine Content of the Vine Leaf. *See Page* 29.)

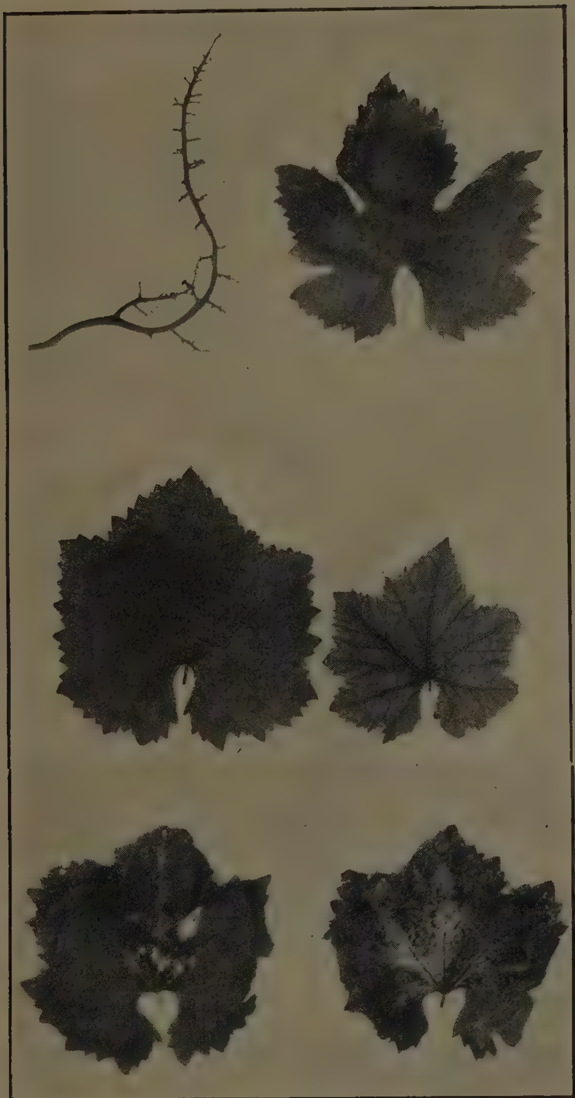

FIG. 1.

Gordo Blanco. Faulty setting of bunch and deposition of chloride along leaf margin.

FIG. 2.

Zante Currant. Normal leaf on left; salt affected leaf (in early stages) on right.

FIG. 3.

Waltham Cross. Chlorosis commencing along veins. Early stage on left, later stage on right.

PLATE 2.

(The Diagnostic Value of the Chlorine Content of the Vine Leaf. *See Page* 29.)

FIG. 1.

Sultana. Normal leaf on left; salt affected leaf on right showing chlorosis and peripheral necrosis.

FIG. 2.

Sultana. Advanced stage of salt injury.

FIG. 3.

Sultana. Mottled areas on old leaves.

# The Diagnostic Value of the Chlorine Content of the Vine Leaf.

*By J. E. Thomas, B.Sc., B.Agr.Sc., B.V.Sc.**

*Summary.*

1. An investigation of the relationship of the soil chlorine content to the leaf chlorine of salt-affected vines in the Murray irrigation areas is recorded.

2. The lesions due to excessive soil salinity are described, and it is shown that there is a close relationship between manifest salt injury, leaf chlorine, and soil chlorine.

3. The chlorine content of the vine leaf, when used with due regard to the factors discussed, is shown to be of considerable value in defining conditions to which the vine is subject. The evidence suggests that concentrations beyond 0.5-0.6 per cent. of the dry matter in the latter part of the season may be considered indicative of excessive soil salinity.

## 1. Introduction.

During a study of salt-affected vineyards in certain of the River Murray irrigation areas, some information was obtained on the relation between soil salinity and leaf chlorine content. This work was extended, and a study was made of the concentrations of chlorine in the leaf, annual wood, and the grape juice in relation to manifest salt injury. This was done with a view to utilizing the data thus obtained as a method of diagnosis to differentiate damage due to excessive soil salinity from that due to insect and fungal attacks, lack of soil moisture, and nutritional disorders.

In the course of soil surveys of these areas, it is found to be quite generally the case that, when the soluble salt content of the soil reaches a significantly dangerous figure, sodium chloride generally constitutes up to 70 per cent. of the total salts present(1). For this reason, the chlorine content of the soil on which the affected vines were growing was taken as a convenient measure of soil salinity. Most of the soils upon which these records were obtained fall within the Mallee group, the characteristics of which have been described by Prescott and Piper(2).

Other investigators have shown that there is a direct relationship between the chlorine in the nutrient solution and the chlorine absorbed. Garner *et al.*(3) obtained a tenfold increase in the chlorine content of the tobacco leaf by the administration of fertilizers containing chlorides; and Pettinger(4) found that, under similar circumstances, increases of the same order could be obtained in the sap of the corn plant. Analogous results were obtained by Lipman, Davis, and West(5), who used wheat plants in solution cultures of varying chloride concentrations. High concentrations of sodium chloride in solution cultures with cereals were found by Hoagland and Martin(6) to depress the absorption of calcium, potassium, and magnesium, while the sodium and chlorine content of the plant increased.

* An officer attached to the Commonwealth Research Station, Merbein.

## 2. Effect of Excessive Soil Salinity on the Vine.

The resistance to salt troubles shown by the three common vine varieties in the Murray areas is considered to be in the order:—Xante Currant, Sultana, and Gordo Blanco.

The effects commonly observed are—

(i) Premature bud burst.

(ii) In extreme cases faulty setting (Pl. 1, Fig. 1).*

(iii) Small leaf size (Pl. 1, Fig. 2).

(iv) Small berry size and low density of grape juice.

(v) Premature wilting and loss of leaves.

(vi) Faulty development and maturation of annual wood.

The leaf reactions are rather definite. The affected leaves are smaller, and early in the season may show signs of chlorosis (Pl. 2, Fig. 1). Later, necrotic areas appear, in many cases preceded by colour changes. These appear, firstly, along the leaf margins, and next between the veins of the leaf. In the final stages, the necrotic areas extend until the chlorophyll bearing area is limited to a strip along the veins (Pl. 2, Fig. 2). The damaged areas are invariably spaced in relation to the leaf venation. If the evaporating power of the atmosphere rises suddenly, the development of the above lesions may take place within a few days. This condition is included in the term "sun scorch," and in such cases may be difficult to distinguish from ordinary wilting.

## 3. Investigational Work.

(*a*) *Methods of Analyses.*

In sampling, from 12 to 20 leaves were removed midway along the growing shoot, and the analytical results were always expressed in terms of the dry weight. The procedure recommended by Husband and Godden(7) was used for the determination of chlorine. The ground sample was mixed with calcium oxide, made into a paste with water, dried on a water bath, and then ignited at as low a temperature as possible.

The resultant ash was then extracted with dilute nitric acid and the chlorides determined by means of Volhardt's method. Other ash determinations were carried out by standard methods. The relative conductivity of the grape juice was expressed as the ratio of the conductivity of the fresh juice to a M/50 solution of potassium chloride measured at the same temperature in a conductivity cell.

(*b*) *Soil Salinity and Leaf Chlorine.*

(i) *Results in Mildura Area.*—During February, 1928, a series of soil and vine leaf samples were selected in a sultana vineyard in which all stages of salt injury were to be observed. Each soil sample was a composite from four holes each to a depth of 18 inches within a 4-ft. radius in each direction from the butt of the vine from which the leaf samples were taken. After making an approximate estimation of

* For Plates see facing page 52.

the number of necrotic leaves on the vine, salt injury was assessed with a maximum of five. This arbitrary scale is, of course, applicable only to this particular case. The results are shown in Table 1.

TABLE 1.—THE RELATIONSHIP BETWEEN SALT INJURY AND THE CHLORINE CONTENT OF THE LEAF AND SOIL.

| Number of Samples. | Scale of Salt Injury. | Mean Values. | | |
|---|---|---|---|---|
| | | Leaf Cl. | Soil Cl. | Total Soluble Salts. |
| | | % | % | % |
| 8 | 5 | 1·55 | ·042 | 0·26 |
| 11 | 4 | 1·11 | ·053 | 0·25 |
| 9 | 3 | 0·99 | ·053 | 0·20 |
| 5 | 2 | 0·94 | ·039 | 0·18 |
| 3 | 1 | 0·54 | ·034 | 0·13 |
| 10 | 0 | 0·63 | ·017 | 0·10 |

It will be noted that there is a close relationship between the manifest salt injury, leaf chlorine, soil chlorine, and total soluble salts.

The furrow method of irrigation is commonly practised in the Mildura district, and, owing to the irregular distribution of percolating water between the furrows, there is a considerable variation in soil salinity. It was for this reason that the above composite method of sampling was adopted. The variability in soil salinity was investigated by making a chlorine examination in three vertical soil sections in a Merbein vineyard. The results, together with the leaf chlorine concentrations are illustrated in Fig. 1. Sections A and B were taken across the vine rows at right angles to the irrigation furrows, while C was taken down the row in the relatively undisturbed soil under the vines. The two former were sampled in March, and the latter in December, 1933.

As a result of 15 years' irrigation of a saline soil, A had become badly salt-affected. B had been irrigated for three years, and the primary effect of irrigation had been to leach the naturally occurring salts below the root range. C had been irrigated for three years only, but on this section the depth of the subsoil free water from the surface varied from 18 inches immediately after irrigation to 50 inches fourteen days later. Following a three weeks' cool period in December, the weather suddenly changed, and the evaporating power of the atmosphere rose steeply. As a sequel, all the leaves on vine 3 died, vine 2 was badly affected, while vine 3 appeared to be unaffected.

The sections illustrate the marked variability in soil chlorine from point to point. In the case of A and B, no evidence of correlation between leaf and soil chlorine is shown, but on the other hand in section C taken down the row there is a very well marked correlation between soil and leaf chlorine and observed salt injury. It seems, therefore, that under these conditions one leaf examination might give much more reliable information than a considerable number of soil analyses.

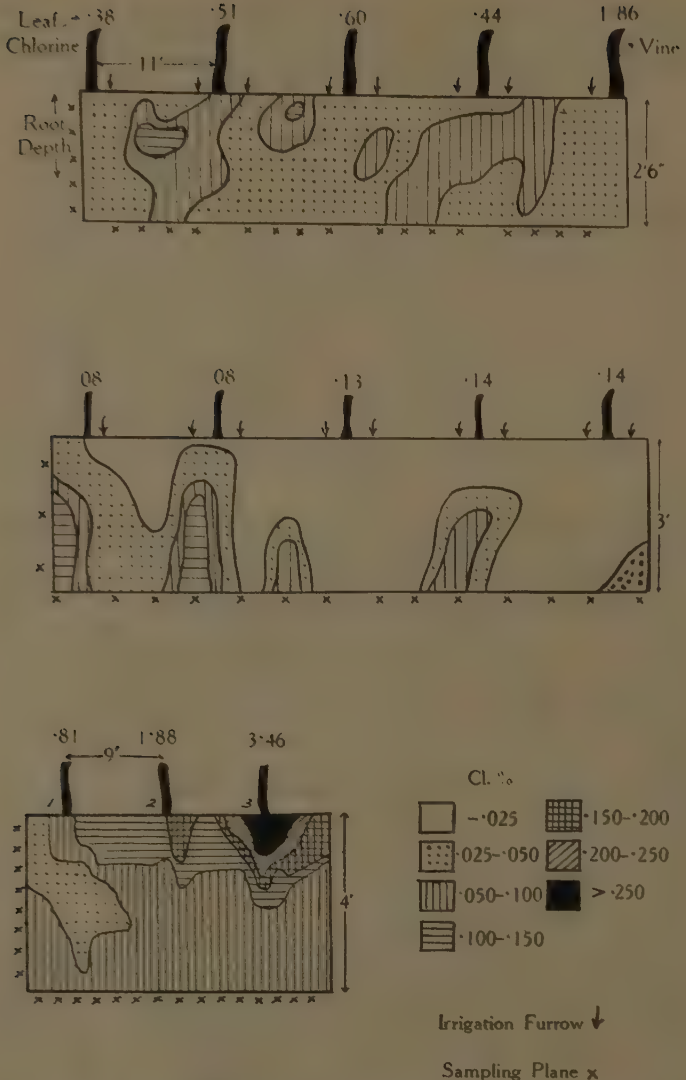


FIG. 1.—Soil chlorine in section. Section A at top. Section B in centre. Section C at bottom. Sections A and B across rows. Section C along row.

(ii) *Results from Other Areas.*—During February and March, 1929, leaf samples from single vines were collected in representative areas along the Murray and examined. Typical results are shown in Table 2.

TABLE 2.—THE CHLORINE CONTENT OF LEAVES FROM VARIOUS LOCALITIES.

| Origin. | Variety. | Leaf Cl. | Remarks. |
|---|---|---|---|
| | | % | |
| **Renmark, S.A.—** | | | |
| (i) .. .. .. | Sultana .. | 0·29 | Occasional salt incidence |
| (ii) .. .. .. | Sultana .. | 0·65 | Salinity effect noted every season |
| **Rutherglen, Vic.—** | | | |
| (i) .. .. .. | Sultana .. | 0·09 | Salt troubles unknown |
| (ii) .. .. .. | Sultana .. | 0·03 | Vines not irrigated |
| **Griffith, N.S.W.—** | | | |
| (i) .. .. .. | Sultana .. | 0·21 | Normal growth |
| (ii) .. .. .. | Sultana .. | 1·74 | Badly affected |
| (iii) .. .. .. | Ohanez .. | 0·04 | Normal growth |
| (iv) .. .. .. | Sultana .. | 2·68 | Badly affected |
| **Tresco, Vic.—** | | | |
| (i) .. .. .. | Sultana .. | 0·18 | Normal growth |
| (ii) .. .. .. | Sultana .. | 2·22 | Badly affected |
| **Waikerie, S.A.—** | | | |
| (i) .. .. .. | Sultana .. | 0·20 | Normal growth |
| (ii) .. .. .. | Sultana .. | 1·43 | Badly affected |

In Nookampka, South Australia, where the soil and climatic conditions are rather similar to Mildura, and where salt troubles had assumed rather serious proportions, a number of additional samples were collected in April, 1932, and examined. The results obtained are given in Table 3.

TABLE 3.—THE CHLORINE CONTENT OF LEAVES AND ANNUAL WOOD.

| Chlorine Content. | | Remarks. |
|---|---|---|
| Leaf. | Annual Wood. | |
| % | % | |
| 4·04 | 0·66 | Vines dead |
| 3·06 | 0·32 | Vines dying |
| 2·30 | 0·26 | Badly affected |
| 2·25 | 0·25 | " " |
| 1·50 | 0·13 | " " |
| 1·16 | 0·15 | " " |
| 0·74 | 0·14 | Slightly affected |
| 0·72 | 0·14 | " " |
| 0·62 | 0·13 | No apparent effects |

The foregoing figures, although they deal with rather extreme cases, illustrate the close relation which exists between manifest salt injury and chlorine content of different parts of the vine. Although the chlorine concentration of the annual wood tends to follow that of the leaves, it is not so closely related to salt injury, and is much smaller in

amount. The high leaf concentration might reasonably be considered as an accumulation at the end point of the transpiration stream, and this appears to go on until a lethal concentration is reached.

The relation between sulphate and chlorine was investigated by some examinations of leaves of varying chlorine contents selected from the same area. The results are shown in Table 4.

TABLE 4.—THE CHLORINE AND SULPHATE CONTENT OF LEAVES.

| Leaf Cl. | Total S. (as $SO_4$). | Inorganic ($SO_4$). |
|---|---|---|
| % | | % |
| 4·04 | n.d. | 0·30 |
| 3·06 | n.d. | 0·14 |
| 2·24 | 0·43 | 0·16 |
| 0·73 | 0·34 | 0·23 |
| 0·72 | 0·54 | 0·29 |
| 0·62 | 0·39 | 0·22 |
| 0·50 | n.d. | 0·16 |

There appears to be little relation between chlorine and sulphate, either total or inorganic, and on these vines sulphate absorption fluctuates between narrower and lower limits.

The foregoing results selected from widely separated areas along the Murray and Murrumbidgee tend to show that the excessive absorption of chlorine is associated with the lesions observed.

*(c) Absorption of Chlorine by the Leaf.*

During the 1931-32 season, the absorption of chlorine was followed by monthly analyses of single vines on two sites. The results are illustrated in Fig. 2. On the site "A," no salt troubles had been experienced, but occasional troubles had been recorded on site "B." It will be seen that, with the advance of the season, there is a marked accumulation of chlorine in the leaves.

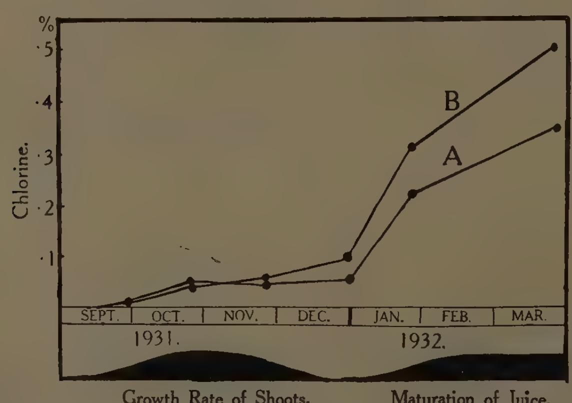


FIG. 2.—Absorption of chlorine.

During 1929-30, a similar experiment had been in progress on other sites, and the results are shown in Table 5.

TABLE 5.—THE CHLORINE CONTENT OF LEAVES OF DIFFERENT AGES.

| Date. | Leaf Cl. | |
|---|---|---|
| | A. | B. |
| | % | % |
| 29.11.29 | 0·03 | 0·09 |
| 12.12.29 | 0·08 | n.d. |
| 24.12.29 | 0·12 | 0·13 |
| 10.1.30 | 1·54* | 0·52 |

* Considerable defoliation occurred.

During November and December, exceptionally cool weather had been experienced. On 25th December, after a week in which the daily evaporation did not exceed 0.300 inches, a heat wave accompanied by strong northerly winds set in, and the evaporation for that day was 0.480 inches. As a sequel, many vines wilted, and the effects varied from temporary defoliation to death. This condition has been included in the term "sun scorch," and has also been described in California(8).

During the heat wave, the chlorine content of the leaves rose to a very high figure—in the case "A" above from 0.12 per cent. to 1.54 per cent. Two other samples from affected vines gave figures of 3.95 per cent. and 2.08 per cent. In all cases, it was noted that the effects were more in evidence in saline and/or heavy soils, in which the absorption of water might fail to meet the sudden heavy demands of transpiration. Under such conditions, the root absorbing mechanism may be disorganized, resulting in the free ingress of chlorine ions.

Immediately after the wilting was observed, seventeen pairs of vines in an affected sultana vineyard were selected, each pair consisting of one wilted vine and one apparently normal vine in close proximity. Composite soil samples to the depth of 1 foot, taken as earlier described, were examined. The mean soil chlorine content of the samples in the first series was 0.065 per cent., and in the second 0.081 per cent., with a standard error of the difference of 0.006 per cent. The difference in the concentration of chlorine—equivalent to about 1¾ atmospheres in the soil solution—is significant, and indicates the relation between soil salinity and "sun scorch." Soil moisture determinations were also made, and, when corrected by means of the sticky-point determination, disclosed no significant differences between comparable pairs.

(*d*) *Chlorine Content of the Grape Juice at Maturity.*

During the month of March, 1930, and again in 1933, samples of the juice of sultana grapes were collected and immediately examined for chlorine and relative conductivity. In addition, chlorine determinations on leaves from the same vines were carried out. The relative conductivity ranged from 1.100 to 1.500, the chlorine concentration of the juice from 0.001 to 0.027 per cent., and of the leaves from 0.30 to 1.20 per cent. As usual, manifest salt injury followed leaf chlorine concentration, but did not appear to be related to the

chlorine content of the juice. For twenty pairs of observations, the correlation coefficient between leaf and juice chlorine was .20, but, on the other hand, the coefficient between leaf chlorine and relative conductivity of the juice was .62 for 32 pairs. This higher value might possibly be explained as an indirect result of chlorine absorption on the maturity process of the grape, particularly as it affects the potassium bitartrate content.

### 4. Diagnostic Value.

Before considering the value of this determination for diagnostic purposes, a short review of the factors influencing it is necessary. The time of sampling is the most important factor to be considered (Fig. 2), and any determination must be interpreted in the light of this absorption curve. Variability from vine to vine on soils of apparently uniform salinity may be considerable. This was studied on a flood-irrigated soil of the Renmark loam type, in which salt troubles were not experienced, and which presumably had a uniform salt content. In April, 1932, samples of leaves were taken from each vine in a plot of 4 by 4 vines. The values ranged from 0.3 to 0.6 per cent., with a mean of 0.43 $\pm$ .02, corresponding to a standard error of approximately 20 per cent. for one observation. Variations of chlorine in leaves from the one vine are usually associated with the age of the leaves. The older basal leaves usually have a higher content than those further out along the shoot. Differences up to 33 per cent. have been observed. The concentration of chlorine in the one leaf increases from centre to periphery, in one example ranging from 0.38 per cent. in the centre to 0.45 per cent. at the periphery.

The distribution of chlorine within the leaf was studied by preparing leaf sections, treating with N/40 silver nitrate solution, exposing to bright sunlight and then removing the chlorophyll with alcohol. In the petiole, the maximum concentration was noted in the phloem parenchyma and the subcuticular parenchyma. The conducting tissue had a considerably higher content than the leaf tissue, although a slight concentration was noted in the lower mesophyll region.

In several instances, a crystalline deposit which gave the reactions for chlorides has been observed on the terminal twigs and on the upper periphery of the leaves. The deposit on the twigs had been noted on vines affected by the "sun scorch" previously described. The leaf deposits were noted early in the season, and were not associated with any noticeable leaf injury. In one instance, faulty setting of the bunch occurred (Pl. 1, Fig. 1), and a subsequent soil examination disclosed the presence of a saline water table close to the surface. In another case, the leaf chlorine in October was 0.15 per cent., but no serious troubles were reported during that season.

Three other well-known types of leaf lesions might possibly be confused with those due to excessive salinity. These are due to (i) fungal and insect attacks, (ii) "senility" and other changes, and (iii) lack of soil moisture. The lesions due to infection with downy mildew (*Plasmopora viticola*), black spot (*Manginia ampelina*), and oidium (*Uncinula spiralis*) are distributed over the affected leaf irregularly without relation to venation, and they can be confirmed microscopically. The convoluted areas due to the attacks of the Erinose mite are rather characteristic, and can similarly be detected. On the older leaves,

brown mottled areas may appear, particularly where sun exposure is considerable (Pl. 2, Fig. 3). These may conveniently be termed "senility" areas, and, as they are distributed irregularly over the leaf, they can readily be distinguished from salt lesions. Typical figures for chlorine in leaves sampled late in the season are—Mottled, 0.53 per cent.; and normal, 0.45 per cent. Very probably, the higher concentration is related to the greater age of the mottled leaves. During December, 1933, after a three weeks' period of cool weather, a leaf condition in the Waltham Cross was observed which is of particular interest since the major change noted—destruction of chlorophyll—commenced first closely adjacent to the vascular tissue, in marked contrast to the effects of salt in which these areas are the last to be affected. (Pl. 1, Fig. 3.) The fifth leaves along the shoots were mainly affected in this manner and the leaf chlorine concentrations ranged from 0.10 to 0.15 per cent., indicating that some other nutritional factor was operating.

It is naturally impossible to sharply define wilting due to lack of soil moisture from that due to salinity of the soil solution. A leaf chlorine examination renders a more reliable diagnosis possible. Some typical examples of differential diagnosis are tabulated in Table 6.

TABLE 6.—SOME INSTANCES OF THE VALUE OF LEAF CHLORINE CONTENT IN DIAGNOSIS.

| Origin. | Sample. | Cl. | Remarks. |
|---|---|---|---|
| | | % | |
| Block E., Renmark—November, 1929 .. | Sultanas—Normal vine .. | 0·01 | Cl. content normal. Field report—death associated with bad physical condition of soil |
| | Dead vine .. | 0·02 | |
| | Dead vine .. | 0·03 | |
| Mildura, Vic.—March, 1929 .. | Sultanas—Chlorosis and early leaf loss | 0·19 | Field examination — water-logging due to adjacent channel |
| Renmark, S.A.—March, 1932 .. | Sultanas—Chlorosis and early leaf fall | 0·71 | Probably associated with excessive soil salinity |
| Nookampka, S.A.—April, 1932 .. | Sultanas—Extreme chlorosis .. | 0·73 | Probably associated with excessive soil salinity |
| Merbein, Vic.—January, 1932 .. | Doradillos—Rapid death of leaves | 0·24 | Field examination—lack of soil moisture |
| Irymple, Vic.—October, 1931 .. | Sultanas—Typical salt lesions | 0·61 | Confirmatory diagnosis of excessive soil salinity |
| Woorinen, Vic.—November, 1931 .. | Sultanas—Death of young growth | 0·01 | Cause obscure—possibly some nutritional factor at work |
| Merbein, Vic.—November, 1932 .. | Xante currant—Normal leaves .. | 0·10 | Field examination—water logging and root injury determined |
| | Chlorotic leaves .. | 0·06 | |

In the case of old vineyards, salt affects may appear as a gradual reduction in yield accompanied by premature leaf fall. Leaf samples collected late in the season may have chlorine concentrations of the order of 0.6 per cent. unaccompanied by any apparent salt injury. Nevertheless, in such instances, it can be safely assumed that the soil salinity is approaching dangerous concentrations.

## 5. Acknowledgments.

It is desired to acknowledge the helpful criticism of Professor J. A. Prescott.

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# A Note on the Wood Structure of *Acradenia frankliniae* Kipp.

*By H. E. Dadswell, M.Sc.,* and Audrey M. Eckersley, M.Sc.**

## 1. Introduction.

*Acradenia frankliniae,* a small tree or shrub, is the only recorded species of the genus *Acradenia,* which belongs to the natural order Rutaceae, and is confined in its distribution to Tasmania. Its botanical characteristics have been described by Bentham† and Rodway.‡ Recently, the timber derived from this species has occasioned considerable interest, for preliminary tests in the laboratories of the Division of Forest Products have indicated that its mechanical properties are very like those of hickory. The special properties of hickory have rendered it the most suitable timber for the best grades of handles and sporting goods, and it is used for such purposes all the world over. The problem of finding an Australian timber which is a satisfactory substitute for hickory has been a difficult one. The interest in the timber from *Acradenia frankliniae* is, therefore, a practical one, and a comprehensive series of mechanical tests is at present being carried out by the Section of Timber Mechanics of the Division. The results of these tests will be published in due course, but, in the meantime, details of the general properties and structure of the wood of this species are given below.

(i) *General Distribution and Size.*—The species occurs chiefly on the west coast of Tasmania, south of the Arthur River, usually in thickets through which it is impossible to pass without cutting a track. It is confined to the gullies, and usually grows on a heavy yellow clay. It has been recorded as growing in the gullies of the Arthur, Pieman, and Gordon Rivers, and their tributaries (Rodway loc. cit.).

Average sized trees grow to a diameter of 5 to 6 inches breast high, while large trees are 10 inches in diameter, with occasional ones up to 15 inches. The total height of the tree varies from 25 to 40 feet, with usually 10 feet of bole free from large branches, but often covered with twig-like branches. The crown is dense and compact. Small trees, up to 2 inches in diameter, occur in dense thickets. The stems of the large trees are usually fluted, but those of the average sized trees are more or less round.

(ii) *Supplies.*—No definite information as to supplies of this timber is available, since it is located in very rough forest country not completely assessed. However, it has been estimated that, in one area, approximately 500,000 super. feet in the round are available. It is at present being milled, and it is possible to obtain supplies for special purposes in Melbourne.

(iii) *Vernacular Names.*—Wirewood, whiteywood.

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* An officer of the Council's Division of Forest Products.

† G. Bentham (1863) "Flora Australiensis," Vol. 1, p. 328.

‡ L. Rodway (1903) "The Tasmanian Flora," p. 23. Government Printer, Hobart.

## 2. General Characteristics.

It is difficult to distinguish between sapwood and truewood, the timber being uniformly white to yellowish white in colour. On a clean, cut, polished cross section, the colour is yellowish-brown. The grain is usually straight, except in the neighbourhood of small knots; the texture is extremely fine and reminiscent of boxwood. The pith is hard and very fine. The samples examined were compartively clear, only a few knots being observed. This, however, does not necessarily mean that lengths of clear timber are common. The basic density range for six samples tested was 37 to 44 lbs. per cubic foot, and the average 40 lb. per cubic foot. This latter figure was the same as the average nominal density based on oven-dry weight and volume when green from a large number of other samples of the same species. The average nominal density for hickory on the same basis is also approximately 40 lb. per cubic foot. A general idea of the cross section appearance of *Acradenia frankliniae* may be obtained from Fig. 1.

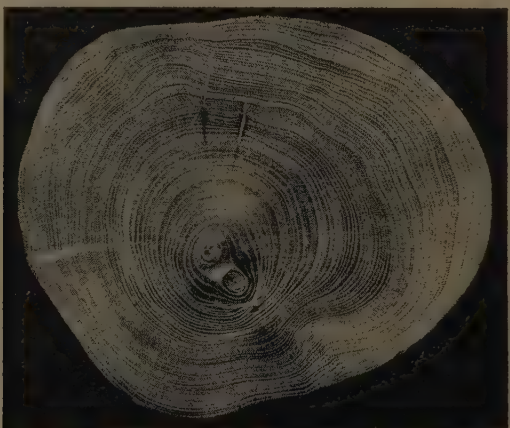

FIG. 1.—Showing the cross-section of a log of *Acradenia frankliniae* 5½ inches in diameter.

## 3. Structure of the Wood.

(i) *Macroscopic.*

*Growth rings* are prominent, being marked by bands of terminal parenchyma, and the larger pores of the early wood. They numbered from 25 to 40 per inch in the different samples examined.

*Pores* are minute in size, invisible separately under lens, and therefore difficult to count, but easily distinguishable against a background of wood fibres as white radial or oblique chains (see Fig. 1). This arrangement, together with that of the parenchyma, makes a very distinctive pattern on the cross section.

*Parenchyma* is visible to the naked eye, in close, fairly regularly spaced zonate bands, which correspond with the limits of the growth rings.

*Rays* are very fine, but distinctly visible under the lens on a cross section.

*Burning Splinter Test.*—Match size splinters burnt to a complete or partial buff-coloured ash.

(ii) *Microscopic.* (See Figs. 2 and 3.)

*Vessels,* more or less angular in cross section, grouped (i) more or less singly in the early wood of the growth ring, giving somewhat the appearance of ring porosity in certain samples; and (ii) in radial rows of 2–12 cells, in the late wood, slightly decreasing in size towards the end of the growth ring; largest vessels 55 to 85$\mu$ in diameter; vessel segments thick walled, often taper-tailed at end; perforations simple, oblique; pits leading to contiguous vessel segments numerous and uniformly distributed, bordered, and with circular orifice; pits leading to parenchyma semi-bordered, numerous, crowded, and sometimes confluent; tyloses absent; gum deposits infrequent; spiral thickenings present.

FIG. 2 (*left*).—A negative print at a low magnification showing the general structure of *Acradenia frankliniae.*

FIG. 3 (*right*).—A photomicrograph of *Acradenia frankliniae* in tangential section. (×77.)

*Parenchyma,* very abundant, arranged mostly in terminal zonate bands 2 to 9 cells wide, cells approximately rectangular or oval in shape; some metatracheal and paratracheal present; pits between cells small, simple, and numerous, arranged in isolated clusters; similar connexions between longitudinal and ray parenchyma.

*Fibres,* rounded in outline, diameter of lumen generally greater than thickness of wall, pits between fibres mainly confined to radial walls, minute, not numerous, and with slit-like orifices.

*Rays,* heterogeneous, 20 to 10 cells high, many biseriate 10–40 per cent., generally more than 30 per cent., some triseriate; cells sometimes containing brown deposits; pits between cells simple, minute and numerous; pits leading to vessels semi-bordered, numerous for each ray cell (up to 20), and sometimes confluent.

(iii) *Material Examined.*—D.F.P. collection numbers 2485, 2486, 2487, 2489, 2490, 2491, 2493.

### 4. Various Properties of the Wood.

(i) *Mechanical Properties.*—As indicated above, these are being fully tested, and results will be published in due course. Preliminary tests have shown that in toughness and hardness this timber may be compared with average hickory.

(ii) *Seasoning.*—No experimental work has been carried out, but from general observations the species should not prove a difficult timber to season. Samples left in the laboratory for some time have not checked badly.

(iii) *Prospective Uses.*—The timber has but recently been placed on the Melbourne market, and direct information as to its present uses is not available. However, from the preliminary tests in which its toughness and hardness have been shown to be similar to those of average hickory, it should be worth a trial for the manufacture of good grade handle stock (preferably small handle), for special jobs in turnery, and possibly for such purposes as mathematical scales. It is essentially a timber for special purposes for which high grade material is necessary.

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# Some Investigations on Rabbit Septicaemia.

*By C. E. Eales, B.Sc.*

Miss Eales is an officer of the Council, who for some time past has been accommodated at the Veterinary Research Institute of the University of Melbourne. Her main work is in connexion with the investigations being carried out under the Empire Marketing Board—Australian Pastoral Research Trust Scheme. (See this *Journal*, 4 : 133; 1931.) She has, however, been able to devote a little time to the study of an aspect of the rabbit problem. Her results are briefly discussed in the paragraphs that follow.—Ed.

In 1897 and 1898, Dr. J. A. Gilruth (Report of Department of Agriculture, New Zealand, 1897 and 1898) carried out experiments in New Zealand on the effects of the dissemination of the organism of chicken cholera among wild rabbits. As rabbits were reported to be fond of pollard, he mixed this with broth culture of the organism, and added sugar to make a more tempting bait. The mixture was made of such a consistency that it could be rolled out and made into pellets, which were then distributed, towards evening, in places frequented by rabbits. Thirty-six hours after each distribution, small numbers of rabbits were found dead outside the burrows, but it was not possible to determine the actual number of deaths among those returning to the burrows. Wild rabbits placed in cages for use as

controls would not eat the pellets; therefore, to make sure of the virulence of the material used, a pellet from each lot was mixed with water and forcibly fed to a rabbit. In every case the rabbit died, usually in from 16 to 24 hours. It was found that the first rabbit to leave the burrow would eat nearly all the available pellets; this probably accounted for the small number of deaths. Captured rabbits were kept in cages until they were sufficiently tame to eat the pellets. After feeding with two or three dry pellets, they showed no sign of illness, but the administration of a small portion of a pellet mixed with water would cause death.

In order to investigate further the question of the effect of the dry state on the virulence of the bacillus, we carried out experiments with an organism of the chicken cholera (Pasteurella) group isolated from a spontaneous case of septicaemia in a rabbit at our laboratory. Heart blood from this rabbit was inoculated into a second rabbit, which died within 24 hours. A third rabbit inoculated with material from the second also died within 24 hours. The inoculations were made intravenously, and the dose was 0.25 cc. Heart blood from the third rabbit was kept in sealed pipettes, and subsequently used for sowing broth culture tubes.

Pollard cubes for feeding experiments were prepared by mixing pollard and a little sugar with 24-hour Pasteurella broth until a stiff dough was obtained. This was cut into cubes and dried overnight in the incubator. It was estimated that each pollard cube contained approximately 2 cc. of Pasteurella broth. Two rabbits were given two cubes each. They ate these, but showed no ill effects. A third rabbit was drenched with one-tenth of a cube emulsified in saline. After three days it was still normal, and was drenched with 2 cc. of Pasteurella broth, with death within 48 hours as the result.

Twelve days after the preparation of the pollard cubes, a rabbit was fed with three of them as a wet mash—and it survived. Two months after preparation, the remainder of the original pollard cubes was fed to a rabbit also in the form of a wet mash. This mash contained approximately 40 cc. of the original broth culture. The rabbit died two months later, but from other causes than septicaemia; the organism was not recovered from the heart blood.

Various drenching experiments with broth cultures were carried out on rabbits, mice, and pigeons, as follows:—

Rabbit 104 was drenched with 0.1 cc. of a 24-hour broth sub-culture of the Pasteurella, and died in sixteen days. Rabbit 105 received 1.0 cc., and died in two days. The organism was recovered from the heart blood of each.

Rabbit 108 was drenched with 0.1 cc., and Rabbit 109 with 0.25 cc. of Pasteurella broth, in each case the culture having been mixed with 5 cc. of sterile broth. Both survived.

Broth cultures were sown from pipettes of heart blood of rabbits dying six months earlier, and were used as follows: Mouse 35 was drenched with 0.1 cc. of 36-hour Pasteurella broth, and died in four days. Mouse 36 received 0.25 cc., and died in six days. Mouse 37 received 0.1 cc., and Mouse 38 received 0.25 cc. intramuscularly: both died in four days.

A pigeon was inoculated intramuscularly with 0.5 cc., and survived.

Two rabbits were drenched with 0.25 cc. and 0.5 cc. respectively of this same culture, and were placed in contact with untreated rabbits. All survived. After four weeks, the two treated rabbits were again drenched, this time with 1 cc. and 2 cc. respectively. Again all survived.

In order to determine whether mixing with pollard would greatly alter the pH of the Pasteurella broth, 3 grams of pollard was added to 15 cc. of 48-hour broth culture, and allowed to remain in contact for three and a half hours. The liquid was separated from the pollard by filtration through paper; its pH and that of the untreated broth were then ascertained by the Comparator method. *Result*—pH of 48-hour Pasteurella broth culture, 6.8; pH of the same broth after three and a half hours contact with pollard, 6.5. The difference does not appear sufficient to account for the non-lethal properties of the pollard cubes.

## Conclusions.

The rabbit septicaemia studied in these experiments was transmissible from subject to subject by intravenous injection of heart blood. The disease could also be produced by drenching with 24-36 hour broth cultures. The ingestion of infected pollard cubes, either dry or in the form of a wet mash, had no effect on the rabbits.

After some months, negative results were obtained on giving broth culture by the mouth, but these were probably due to loss of virulence of the organism. These same broth cultures were pathogenic for mice but not for pigeons.

The mixture of pollard with Pasteurella broth altered the pH of the latter only from 6.8 to 6.5. We are, therefore, led to conclude that the lack of virulence shown by the pollard cubes is due to the paralyzing effect of their dry condition on the activity of the micro-organisms, and not to any great alteration in the pH of the medium. The measure of success obtained by Dr. Gilruth in the killing of wild rabbits may have been due to the facts that his pellets were used when quite fresh, and that a large number were eaten at once by individual rabbits.

# Mouse Plague Investigations.

*By D. Murnane, B.V.Sc.**

*Summary.*

1. Some of the causes of the rapid termination of a mouse plague have been studied.

2. Exposure and cold or wet weather account for heavy mortality.

3. A fatal infectious disease has been observed. The causal organism has been isolated and identified as *B. enteriditis* Gaertner—one of the food poisoning ("ptomaine") group affecting human beings.

4. The disease is readily transmitted to mice by ingestion, but, being infectious for man, it cannot be employed in the control of mouse plagues.

5. It is likely that certain cases of illness in domesticated animals following mouse plagues are due to infection with this organism via contaminated fodder.

6. The fact that mice act as carriers of this infection is of importance from the point of view of human health.

## 1. Introduction.

In 1932, Victoria experienced one of the severe mouse "plagues" which periodically visit country districts and cause much damage and destruction, particularly in the wheat areas. Occasionally, other pests such as grasshoppers, caterpillars, rabbits, and hares assume "plague" proportions.

Whence these pests suddenly come, why they should appear in such enormous numbers only at intervals of several years, why they disappear as suddenly as they come while there is yet abundance of food—particularly in the case of mouse plagues—and whither they go, seem to be questions to which a complete answer is not yet available.

Some observers are strongly of the opinion that in the case of mice, rabbits, and hares, the plagues are the result of a general migration of animals to one district. In support of this, they point out two facts:—(i) that the hordes of vermin usually move as an army in a definite direction, small parties advancing ahead of the main body; and (ii) during a plague it is unusual to see young animals or pregnant females, the inference being that the presence of such vast numbers is not the result of local multiplication.

Some have credited the Nullarbor plain with being the breeding ground of the last mouse plague, but it would seem quite impossible for mice to migrate from there to the Mallee in Victoria—a distance of several hundred miles.

That few young animals or pregnant females are seen in wheat or hay stacks during plague periods possibly may be because the females have their young in burrows or tunnels in the ground. In fact, the burrow is the normal habitat of the species under ordinary conditions. They are very prolific, having several litters of six to ten young during the season.

* Veterinary Research Officer, Division of Animal Health, located at the Veterinary Research Institute of the University of Melbourne.

The animals in question are commonly referred to as "field mice," but, contrary to popular opinion, they are actually of the same species as the ordinary "house mouse" (*Mus musculus*), the colour of which may range from light-grey to brown, depending upon locality. The individuals living under field conditions are usually smaller and more agile than those which frequent dwellings.*

*Economic Importance.*—The losses, direct and indirect, which mice cause to wheat-growers undisputedly run into very many thousands of pounds, brought about chiefly by (i) the eating of sown seed, (ii) the eating of grain in stacks, (iii) the destruction of sacks, allowing the grain to run out, and causing collapse of stacks, (iv) the fouling of grain, and (v) the extra cost of handling, re-bagging, and re-conditioning loose grain.

The problem obviously is that of effective destruction of the vermin.

*Mortality in the Field.*—It is a striking fact that the hordes eventually disappear very rapidly. This sudden disappearance while food is still plentiful must have an explanation, and led to the consideration of at least two possible causes:—

(*a*) The effect of the onset of cold and wet weather.

(*b*) The outbreak of a specific infectious disease.

In the event of the latter being responsible, if the nature of the disease could be established and the causal organism isolated, it may be possible to assist in the control of future plagues by the dissemination of such disease throughout the mouse infested stacks by liberation of inoculated mice. There is nothing original in this idea, as it has been tried in the past and results have been unsatisfactory.

While it may be an easy matter to spread infection by contact in the case of caged animals, the same does not hold true for animals at large under natural conditions. In the case of mice during a plague, however, the position is somewhat different, as here the animals are so extremely numerous that they are huddled together in very close contact.

It was accordingly decided, by the Division of Animal Health, that the matter should be looked into, and a visit was made to a country centre where large quantities of wheat were stacked at the railway station, and where, it was reported, the plague had passed its height and the mice were dying in large numbers. A close inspection of the wheat stacks and railway yards revealed large numbers of dead mice, but post-mortem examinations failed to provide any evidence of infectious disease. Mange and favus ("ringworm") were common, and will be referred to later.

At this stage, it appeared that the mortality was due chiefly to four causes:—

(i) *Suffocation in Burrows.*—Presumably on account of the onset of cold nights (April), burrows which normally harbour two to three mice were found packed tightly by upwards of a dozen or twenty animals, those towards the entrance pushing and crowding inwards so forcibly

* For the identification of the mice and information concerning them, the writer is indebted to Mr. Brazenor, of the National Museum, Melbourne.

that the animals in the blind end of the burrow were suffocated. In tunnels where the mice at the end had not been suffocated, it was common to find them thoroughly saturated with perspiration.

(ii) *Cold and Exposure.*—Some deaths were due to cold and exposure, to which field mice seem particularly sensitive.

(iii) *Violence.*—Many of the deaths in the stacks were undoubtedly of traumatic origin, due to sudden slipping of bags of grain. As holes are eaten in the bags of the lower tiers, the wheat runs out, causing a collapse of these bags and a consequent "land slide" of the upper tiers, resulting in the crushing and suffocating of thousands of mice.

(iv) *Favus* ("*Honeycomb Ringworm*").—This was found to be responsible for a considerable percentage of deaths. Favus is due to the fungus *Achorion,* of which various species are pathogenic for man and the lower animals. *A. quinckeanum* is the common mouse favus, and may infect man. In the mouse, the lesions consist of a well defined accumulation of mycelia forming a concave yellowish disc or scab, the periphery of which usually presents a rolled appearance. The lesions are most frequently situated on the head in the vicinity of the eyes and mouth, and often reach such proportions as to render the animal blind or unable to open the jaws, death eventually resulting. (See Fig. 1.) The condition is readily transmitted from mouse to mouse.

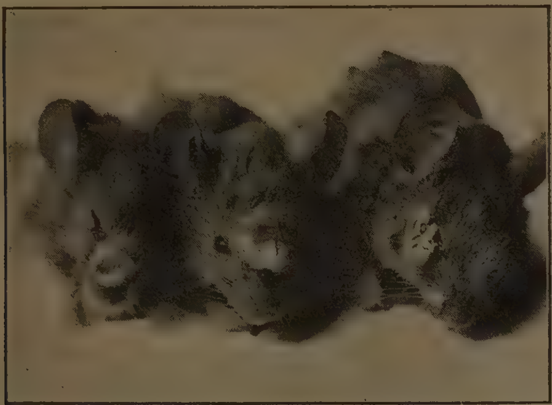

Fig. 1.—Mice showing lesions of favus ("ringworm") *Achorion quinckeanum.*

## 2. Deaths by Disease.

Later, however, mice were found to be succumbing to an infectious disease. Post-mortem examinations commonly revealed the presence of numerous large yellowish nodules in the liver, and less frequently in the spleen. Smears of pus from lesions showed numerous short, Gram-negative, round-ended bacilli. While this organism (which will be referred to as M5) was being subjected to cultural and fermentation tests for purposes of identification, its pathogenicity was studied. Twenty-four hour serum broth cultures were mixed to a mash with

pollard, which was then made available to several groups of field mice in containers; adequate controls were kept. After four days, deaths commenced in the fed mice, and post-mortem examinations revealed typical liver lesions from which the small Gram-negative bacilli were recovered. These experiments were repeated with uniform results. Thus, up to this point, the possibility of utilizing this organism seemed to offer some prospects. The next step was the identification of the organism, which has the following characteristics:—

*Morphology.*—Short, round-ended, Gram-negative rods occurring singly. Strongly motile.

*Cultures.*—*Serum Agar Slope*—abundant, beaded, smooth, glistening, flat, white, opaque. Separate colonies circular, entire.

*Agar Slope*—abundant, spreading, white, thick, opaque.

*Agar Stab*—some surface growth. Growth throughout stab. Medium split.

*Loeffler's Serum*—abundant, moist, white. Granules in condensation moisture. Medium darkened. No liquefaction.

*Potato*—growth dirty yellow. Medium grey.

*Gelatin*—no liquefaction. Pinnate growth in stab.

*Serum Broth*—pellicle, strongly turbid with deposit. Refractile particles appear later.

*Beef Infusion Broth*—pellicle, strongly turbid with deposit. Refractile particles appear later.

*Litmus Milk*—acid, grey-green ring at top. No clot. Later becomes alkaline.

*Indol*—negative.

*Nitrates*—reduced to nitrites.

*Fermentation*—acid and gas in glucose, levulose, maltose, galactose, mannite, rhamnose, dulcite, xylose, arabinose, sorbite. No change in lactose, raffinose, glycerin, salicin, inulin, dextrin, saccharose.

Referring the above morphological, cultural, and fermentation characters to Bergey's classification (Bergey's Manual of Determinative Bacteriology), it would appear that this organism falls within the Salmonella group, strongly resembling *B. aertrycke*, *B. enteriditis* Gaertner, and *B. paratyphosus* B. (food poisoning organisms).

Being so closely related, the differentiation of these organisms becomes a matter of serological tests. Accordingly, tests were carried out with standard *Aertrycke*, *Paratyphosus* B. and Gaertner agglutinating sera (Commonwealth Serum Laboratories) against our organism. *Aertrycke* serum (of titre 1 in 3,000) gave incomplete agglutination even in 1 in 100. *Paratyphosus* B. serum (of titre 1 in 2,000) gave no appreciable agglutination. *B. enteriditis* Gaertner serum (of titre 1 in 2,500) gave complete agglutination up to 1 in 800, and partial in 1 in 3,200.

As it therefore appeared that our organism more closely resembled *B. enteriditis* Gaertner, the following agglutination and absorption agglutination tests were made:—

1. Unabsorbed Gaertner serum against Gaertner emulsion. Titre—1 in 5,120.

2. Gaertner serum absorbed with M5 against Gaertner emulsion. No agglutination.

3. (*a*) Gaertner serum absorbed with Gaertner against M5 emulsion. No agglutination.

(*b*) Gaertner serum absorbed with Gaertner against Gaertner emulsion. No agglutination.

Further, a serum against M5 was prepared, and the following tests were made:—

1. Unabsorbed M5 serum against—
   (*a*) M5 emulsion. Agglutination up to 1 in 10,240.
   (*b*) Gaertner emulsion. Agglutination up to 1 in 10,240.
2. M5 serum absorbed with Gaertner against—
   (*a*) M5 emulsion. No agglutination.
   (*b*) Gaertner emulsion. No agglutination.
3. M5 serum absorbed with M5 against—
   (*a*) M5 emulsion. No agglutination.
   (*b*) Gaertner emulsion. No agglutination.

(*B. pullorum* was agglutinated, but, as M5 is strongly motile, it could not be confused with *pullorum*.)

*Conclusion.*—The organism (M5) under investigation appears to be *B. enteriditis* Gaertner.

### 3. Discussion.

It is quite possible that illness in domesticated animals following ingestion of "mousey" grain, hay, or chaff during mouse plagues is in certain cases due to infection with this organism.

David (*Wien. tierarztliche Mschr.* 19, p. 41) abstracted in the *Veterinary Bulletin*, Vol. 2, No. 11, p. 597, reports outbreaks of disease in cattle in Europe, which he attributes to infection with organisms of the food poisoning group, and incriminates brewers' grains as the vehicle.

It has been pointed out by Lovell (*Vet. Bull.*, Vol. 3, No. 4, p. 179) that the original *B. enteriditis* was isolated from a bovine by Gaertner, and that since then, there have been numerous records of infection of cattle by this organism and the closely related "Dublin" type. Mortality in some cases has been high. From the above absorption agglutination tests, it will be seen that our organism is not the "Dublin" type. ("Dublin" emulsion is not capable of completely removing agglutinins against *B. enteriditis* from *B. enteriditis* serum, whereas emulsion of our organism is.)

From the point of view of human health, the finding is of significance, showing, as it does, how mice readily act as carriers of this food poisoning (so called "ptomaine" poisoning) organism. This is of particular importance to residents in mouse plague areas, and to those handling infected mice and contaminated grain.

# The Effect of Arsenical Sheep Dip on the Germination of Noogoora Burr Seeds.

*By J. Calvert, M.Sc.**

## 1. Introduction.

Since its accidental introduction in cotton seed some 50 years ago, *Xanthium pungens* Wallr. (known as Noogoora burr, from the Noogoora Station, near Brisbane) has become a serious problem in Australia.

Dr. White-Haney†, who examined the distribution phase of the problem, found that rainfall, more than any other single factor, influences the rate and area of establishment of the burr. The plant is an annual, or is perhaps better described as a "seasonal," and each burr contains two seeds which usually do not germinate at the same time. The breaking of a drought is followed by large crops of burr, and the movement of stock on agistment helps to spread the pest. These facts make it impossible to give a reliable estimate of acreage.

In 1929, Dr. White-Haney, at the request of Dr. B. T. Dickson, arranged to test the effect on burr germination of arsenic pentoxide used as a plant spray. She could plant the burrs only during the winter, and as a result, even normal germination was delayed, but it appeared that there was an inhibitory effect produced by the arsenical solutions used.

Following a recent inquiry as to the effect of sheep dip on seeds of Noogoora burr, the writer was asked to investigate the matter, and the results are here reported.

## 2. Experimental.

Three experiments were designed to cover the whole question, namely:—

(i) A comparison of the germinations of dipped and undipped burrs.

(ii) The germination of dipped and washed burrs.

(iii) Testing for the presence of arsenic—

(*a*) on the burrs,

(*b*) in the seeds.

For Experiment I., 100 burrs were embedded in a portion of a fleece, and the whole immersed in a solution of a commercial sheep dip (Dip No. 1) of the strength ordinarily used. Another sample of 100 burrs, also embedded in wool, was immersed in a solution of Dip No. 2, which was prepared according to the directions. Both dips used are common arsenical dips, the prepared solution of Dip No. 2 containing .2 per cent. arsenic compounds, and .1 per cent. phenol. The burrs were kept immersed in their respective dips for nearly 45 seconds,

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† *J. Coun. Sci. Ind. Res.* (Aust.), 3: 77, 1930.

after which they were allowed to dry naturally. The burrs used were collected in Queensland in 1929, and since then have been stored in the laboratory of the Division of Plant Industry, Canberra. When the "burry" wool samples were dry, the burrs were freed from the wool and planted in large pots. In addition to these two samples of 100, a futher sample of 100 untreated burrs was also planted.

It is possible for the arsenic which has dried on the outside of the burrs to sterilize the soil in the immediate vicinity of each burr when planted, and thus poison the young radicle if it emerges. Hence, in Experiment II., 75 burrs, embedded in wool, were dipped in a solution of Dip. No. 2, as in the previous experiment, and allowed to dry. These burrs were then freed from the wool and washed thoroughly for two days, and 50 of them placed in wet flannelette in germination trays. The remaining 25 were planted in pots as in Experiment I.

In Experiment III., a number of burrs were dipped as usual, and after being freed from the wool when dry, the two seeds were taken out of each burr. The collected seeds were then ground and tested for arsenic by Marsh's test, as also were the seedless burrs.

## 3. Results.

Experiment I.—Germination of Dipped and Undipped Burrs.

| Treatment. | 100 Burrs in Dip. No. 1. | 100 Burrs in Dip. No. 2. | 100 Burrs Untreated. |
|---|---|---|---|
| Germination .. .. .. | Nil | Nil | 84 |

Experiment II.—Germination of Dipped and Washed Burrs.

| Treatment. | On Germination Trays. | In Soil. |
|---|---|---|
| | 50 Burrs dipped in Dip. No. 2, dried, and washed. | 25 Burrs dipped in Dip No. 2, dried, and washed. |
| Germination .. .. .. | 1 (Radicle weak, brown at tip) | 2 |

Experiment III.—Test for Arsenic in the Seeds and Seedless Burrs.

| — | Arsenic. | |
|---|---|---|
| | Ground Seeds. | De-Seeded Burrs. |
| Marsh's Test .. .. .. | + | +++ |

## 4. Discussion.

In the first experiment, there is a definite effect produced on the germination of the burrs by the two dips used. This observed inhibition of germination must be due to either the sterilization of the soil surrounding each burr by the arsenic on the outside of the burr, or the destruction of the viability of the seed by the actual entrance of arsenic. Inhibition of germination is shown in Experiment II. to be due, in the main, to the entrance of arsenic into the seed, brought out by the fact that the removal of the soil sterilization factor does not induce any great increase in germination.

On testing for arsenic, the idea that arsenic actually enters the burrs in sufficient quantity to destroy the viability of the seed was confirmed. Apparently, the occasional seeds which escape destruction by arsenic are poisoned when the radicle emerges into the sterile soil.

## 5. Conclusion.

The results of this investigation show that the two sheep dips tested destroy the viability of the seeds of Noogoora burr when subjected in the laboratory to a treatment comparable to that which would be received in the ordinary process of sheep dipping.

# NOTES.

## The Commonwealth Fund Fellowships.

The Trustees of the Science and Industry Endowment Fund are frequently approached for grants to enable graduates to go abroad for the prosecution of advanced studies. Owing to limitations of income, it is all too often impossible to assist people of great promise who would profit immensely from further training in other countries. There are, however, other possibilities which seem to be insufficiently known, and one of these is briefly discussed in the following note by Dr. Noel S. Bayliss, Senior Lecturer in Chemistry in the University of Melbourne, who was himself a Commonwealth Fund Fellow for some time at the University of California. His note should be of interest to graduates in the Public Service.—Ed.

The Commonwealth Fund, an American philanthropic trust with headquarters in New York, was founded by Mrs. Stephen Harkness in 1918, with the fairly comprehensive aim of "doing something for the welfare of mankind." Since then, it has been active in promoting rural medical services in the United States, and in the establishment of clinics for child welfare in the poorer districts of London and Vienna. In 1924, the Commonwealth Fund Fellowships were founded in the hope of fostering a feeling of goodwill and understanding between the English and American peoples. At first, the fellowships were offered only to graduates of English universities; but, in 1929, the additional "Service Fellowships" were made available to members of the overseas services of the British Government, and to members of the Government services of British Dominions and Colonies. In the former category, about 30 fellowships are available annually, with the restriction that candidates must be under 30 years of age and unmarried. These restrictions are removed in the case of the Service Fellowships, about seven of which are offered each year.

The Fellows are required to pursue advanced studies or research work for two years at an American university, considerable freedom being allowed in the choice of subject and university. The facilities for research in the United States are good, especially in subjects of a scientific or "practical" nature, and Fellows have studied such subjects as agriculture, anthropology, architecture, banking, business administration, irrigation engineering, forestry, political science, and economics, as well as the fundamental sciences, mathematics, classics, and literature.

Emphasis is laid on the necessity for travelling in order to gain an impression of the United States as a whole, the travelling to be done principally in the short Christmas vacations and in the long summer vacation at the end of the first year of the Fellow's residence in America.

As mentioned before, the Fellowships are tenable for two years, and the stipend is \$150 a month. In addition, allowances are made for the journey between the Fellow's home and the United States, an extra \$750 is allowed for travelling during the summer vacation, \$200 is allowed for each Christmas vacation, and all university and laboratory fees are paid by the Commonwealth Fund. Although the cost of

living in the United States is regarded as being high, it is found that this allowance is adequate even in New York, and that Fellows stationed at universities in the West or Middle West are enabled to live more than comfortably.

The selection of candidates is in the hands of an English committee, whose honorary chairman is the Prince of Wales, and which includes representatives of the principal English universities. The secretary of the English Committee of Award is Richard H. Simpson, 35 Portman-square, London, W.1, who is able to furnish application forms and all necessary information, and to whom all applications should be posted to arrive in the first week in February in any given year.

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## A Co-operative Soil Survey of the Denmark Area, Western Australia.

During a visit to Western Australia in 1930, Dr. J. A. Gilruth, Chief of the Council's Division of Animal Health, was consulted by officers of the W.A. Department of Agriculture who were engaged in the investigation of an obscure disease affecting cattle in the Denmark district of Western Australia. As a result, a conference of veterinary officers considered it probable that the complaint was associated with some deficiency in the mineral content of the pastures. The Department of Agriculture accordingly arranged for a series of extensive experiments to be carried out under the direct charge of Mr. J. F. Filmer, B.V.Sc., veterinary officer of the Department, and it soon became apparent that the malady was one which affected sheep as well as cattle.

Mr. Filmer has established the fact that the disease is definitely of a nature similar to that known as " bush sickness " in New Zealand, which is deemed to be due to a deficiency of iron in the soil and herbage. While it may be prevented by the administration of certain compounds of iron, and affected animals may even recover under treatment, Mr. Filmer's researches indicate that other factors may be of great importance.

As a result of a request made to the Council by Mr. G. L. Sutton, Director of Agriculture, Western Australia, of a preliminary report by Mr. J. S. Hosking, B.Sc., Assistant Research Officer, Division of Soils, and of discussions which Professor J. A. Prescott has had with Dr. L. J. H. Teakle, Research Officer of the Department of Agriculture of Western Australia, arrangements have now been completed for a soil survey to be made of the Denmark area. This is being undertaken in view of the possibility of the disease occurring on new areas opened up for settlement, and for the purposes of defining and mapping the soil types and correlating the incidence of the disease with soil types.

The area to be surveyed comprises about 100 square miles, being the western portion of the district of Plantagenet, west of the Denmark River. The work will be a joint enterprise of the Council and the Department, the arrangements being that the Division of Soils will undertake laboratory examinations and the publication of the data, and officers of the Department of Agriculture of Western Australia, under Dr. Teakle's guidance, will undertake the field work and the preparation of a soil map.

## Chilled Beef—Experimental Shipment by M.V. "Idomeneus."

In the last number of this Journal, an article was published on "The Use of Carbon Dioxide in the Storage of Chilled Beef," and it was pointed out that, as a result of an experiment conducted by the Council's Section of Food Preservation and Transport in co-operation with the Queensland Meat Industry Board, it had been shown that chilled beef could safely be kept under certain conditions for a period of 53 days.

Arrangements have now been made for an experimental shipment of chilled beef to be sent from Queensland to London by the Blue Funnel Line M.V. *Idomeneus*, which has been provided with a special "gas-tight" chamber of about 7,000 cubic feet capacity and which will sail from Brisbane for London early in February, 1934. Mr. N. E. Holmes, B.E.E., an officer of the Council, is travelling to Australia on the *Idomeneus*, and is conducting gas tests in the chamber during the outward voyage. He will return to England on the vessel for the purpose of making accurate observations of the physical conditions obtaining in the chamber during the voyage, which it is anticipated will not take more than 45 days.

The beef will be shipped from Brisbane on behalf of several exporters, and its preparation and stowage will be supervised by the Queensland Meat Industry Board in accordance with details furnished by Dr. J. R. Vickery, Officer-in-charge of the Council's Section of Food Preservation and Transport. Steps have been taken to secure the co-operation and assistance of the British Food Investigation Board with a view to obtaining full reports, which will enable the condition of the meat on arrival in England to be correlated with the conditions prevailing in all stages of preparation and transport.

It is hoped that, as a result of the knowledge and experience gained from this shipment, it will be practicable, not merely to confirm the applicability to commercial conditions of the results obtained in the laboratory and in the experimental chambers at Brisbane, but also to determine accurately the conditions which must be fulfilled for the successful transport of chilled beef from Australia to England.

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## The Buffalo-Fly—Its Occurrence in North China.

In connexion with the spread of the buffalo-fly (*Lyperosia exigua*) pest in Australia (see this *Journal* 4 : 234, 1931), considerable attention has been given to the question of carrying out experiments for the purpose of obtaining definite knowledge as to the temperatures and humidity conditions under which it can pass through its life history, and thus of determining the geographical limits of its possible spread in Australia. It might be thought that the limits of spread could be determined by a careful study under laboratory conditions of the reactions of the fly to different temperatures and humidities. Although this may be possible at some future date when more is known about the interactions between the insects and their environment, Dr. A. J. Nicholson, the Acting-Chief of the Council's Division of Economic

Entomology, is of the opinion that it is not possible to do so at present, however elaborate the experiments may be. As far as he is aware, the possible limits of spread of any insect have not yet been determined successfully as a result of laboratory experiments.

If attempts were made to breed the insect in insectaries in certain places in Australia in order to determine whether *L. exigua* can pass through its life history under the climatic conditions in these places, difficulties would first of all arise in maintaining adequate quarantine conditions. The main objection would, however, be that all attempts to breed the buffalo-fly through more than one generation in captivity have been unsuccessful even under the most favorable climatic conditions. Consequently, a negative result obtained in an insectary at any place could not be accepted as evidence that *L. exigua* could not pass through its life history in that place.

The Division of Economic Entomology recently obtained evidence that *L. exigua* had been recorded by Professor W. S. Patton, Liverpool University, as common in northern China. Dr. A. J. Nicholson has accordingly been in communication on the matter with Sir Guy Marshall, Director of the Imperial Institute of Entomology, who has ascertained that the species of buffalo-fly obtained by Professor Patton from northern China is undoubtedly *L. exigua*.

Sir Guy Marshall has also expressed the opinion that, in view of the occurrence of *L. exigua* in northern China, the probability of its being able to maintain itself in the coastal regions of southern Australia is very high. On the information available, he would strongly oppose any suggestion for the relaxation of quarantine regulations in connexion with the matter in Australia. He points out that there can be little doubt that the buffalo-fly is able to adapt itself to very diverse conditions, seeing that *L. irritans,* which was originally a fly of temperate climates, has of recent years been able to establish itself in the tropics, as, for example, Hawaii and Jamaica. He thinks it extremely improbable that *L. exigua* would be unable to live in the coastal districts of New South Wales.

The maintaining of quarantine regulations is not a matter which comes within the functions of the Council, which has, therefore, communicated to the appropriate authorities the facts and opinions referred to above.

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## A Disease Affecting the Australian Rabbit.

Some twelve months or so ago, the Pasture Protection Board of Bourke, New South Wales, drew the attention of the Council for Scientific and Industrial Research to an outbreak of disease which had occurred in rabbits in north-western New South Wales. Apparently, the disease had been observed in the far west of the State, and had gradually extended eastwards.

The possibilities of controlling the rabbit pest by the dissemination of disease are not particularly encouraging (see this *Journal* 5: 189, 1932). Nevertheless, in view of the importance of the whole matter, the Chief of the Division of Animal Health (Dr. J. A. Gilruth) visited Bourke and the surrounding districts. He was unable to obtain any evidence in the field that the disease was contagious, or, if so, to such

an extent that it was likely, by artificial means of propagation, to be of any value in controlling the rabbit pest. Few, if any, symptoms were exhibited prior to death, which occurred fairly suddenly without evidence of previous struggling. A post-mortem examination of rabbits immediately or soon after death showed that the animals were almost always in good condition, that no internal parasites were present, that the blood contained no infective agent generally determinable either by microscopical examination or by blood inoculation in healthy animals, and that putrefaction set in much sooner after death than occurred in rabbits killed by violence (shooting), at the same time. The general post-mortem appearance of the dead rabbits, particularly the heart and the kidney, approximated that seen in sheep and lambs dead of entero-toxaemia, which disease (originally described by Dr. Gilruth) has been extensively studied by Dr. H. W. Bennetts and Mr. D. T. Oxer, by the former in connexion with the so-called braxy-like disease of sheep in Western Australia (see the Council's Bulletin, No. 57), and by the latter in connexion with pulpy kidney disease in Tasmania (see the Council's Pamphlet, No. 35). This was confirmed by a subsequent microscopical examination of tissues.

At the time, facilities did not exist for securing and transmitting to the laboratory intestinal contents for experimental work, but arrangements were made for the collection of such material later, should the mortality recur. As yet, no such recurrence has been reported. Should another outbreak occur, every effort will be made to ensure a full examination, although it is not anticipated that the disease will be of much value as a practical means of reducing the extent of the rabbit plague. The work may, however, quite easily prove valuable in connexion with the study of entero-toxaemia in general.

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## The Division of Animal Health—Appointment of Dr. L. B. Bull, D.V.Sc.

Dr. L. B. Bull, who has recently been appointed to the position of Deputy-Chief of the Council's Division of Animal Health, will leave Australia by the s.s. *Hobson's Bay* on the 20th February on a visit to Great Britain and Europe, where he will inspect a number of research institutions and inform himself as to recent developments in veterinary research, and establish contacts with his colleagues. He will probably return to Australia via South Africa in order to visit the well-known research laboratories at Onderstepoort, and will be absent from Australia for about eighteen months.

After graduating at the University of Melbourne, Dr. Bull was appointed in 1912 to the position of Bacteriologist and Veterinary Pathologist to the South Australian Government Laboratory of Pathology and Bacteriology. He was appointed Deputy-Director of the Laboratory in 1918, and Director in 1925.

In his work at Adelaide, Dr. Bull has established a wide reputation. In addition to his diagnostic work, he has carried out valuable research on a variety of animal health problems. During recent years he has been closely associated with certain animal health investigations conducted by the Council, particularly with respect to haematuria (redwater in cattle), caseous lymphadenitis, and coast disease.

## The "Index Veterinarius"—A New Periodical.

It has for long been realized by people concerned with scientific research that the ever-increasing attention being given to scientific investigations in all progressive countries of the world is rendering it more and more difficult for any individual worker to inform himself of all the developments arising in his particular branch of science.

One of the objects of the 1927 Imperial Agricultural Research Conference was to develop machinery for overcoming this problem in so far as it affected the various branches of science which have become important of late as a result of the intensive application of scientific methods to agricultural practices. Since 1927, considerable progress in that direction has been made by the various Imperial Agricultural Research Bureaux set up to cover these special fields. For instance, each Bureau is now issuing some sort of publication in which abstracts of articles appearing in a wide range of journals, both English and foreign, are given.

The Imperial Bureau of Animal Health has recently decided to publish an "Index Veterinarius" in addition to its abstracting journal —the *Veterinary Journal*. Like that Journal, the Index will cover a very large number of English and foreign veterinary publications, and will, in fact, be a very complete index to publications relating to veterinary research, public health, administration, and education.

Each volume of the new publication will cover one year, and will be issued in four parts at quarterly intervals. The annual volume will be in crown quarto size, and will run to about 1,600 pages. About 10,000 references will be indexed each year, each reference being suitably cross-indexed alphabetically both under the names of authors and subjects, and with cross-indexing there will be about 50,000 insertions in a volume. All the information will be readily found, as each quarterly issue will consist of a single complete alphabetical index of authors' names and of subjects. The publication will be prepared on a Gestetner duplicator. The first quarterly issue, dated April, 1933, and covering the first quarter of the year 1933, has recently become available in Australia.

The price of the new publication is £4 per volume, including packing and postage. There will be no free issue. Orders should be sent to the Imperial Bureau of Animal Health, Veterinary Laboratory, Minister of Agriculture and Fisheries, Weybridge, Surrey, England.

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## Dried Fruit Investigations—Offer by Mildura District Packing Companies.

The Council has recently received an offer, by four dried-fruit packing companies in the Mildura district, to subscribe between them the sum of £1,000 per annum for three years to make possible an investigation into the fundamental principles of dipping and processing dried fruits, particularly sultanas. It is believed that if these principles were better known than they are at present, it would be possible to develop improvements in present commercial practices.

The Council realizes that the work, involving as it does a study of enzyme and other actions taking place from the time the fruit ripens on the vine till it is consumed overseas, requires rather special qualifications in any research worker who may be allocated to it. Provided, therefore, that the services of a suitable investigator can be obtained, the offer will be gladly accepted. Applications for appointtion to the position have already been invited, and those received are now under consideration.

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## Recent Publications of the Council.

Since the last issue of this *Journal,* the following Pamphlets of the Council have been published :—

*Pamphlet No.* 46.—"The Holding Power of Special Nails" (Division of Forest Products—Technical Paper No. 11), by Ian Langlands, B.E.E.

A knowledge of the holding power of nails is of value particularly in connexion with the manufacture of wooden cases, as by far the commonest cause of failure in such cases is due to the pulling of the nails. The Pamphlet describes the results of tests of over 4,000 nails, representing fifteen types of special nails and two makes of plain nail, all of which were tested for static and impact holding power. Tests were carried out on nails driven into dry wood and pulled immediately, and on nails driven into dry wood and pulled three months later when the wood had reached a somewhat lower moisture content. The results have shown that the rusted nail has the highest static holding power, while the twisted nails have the highest impact holding power. When static and impact holding powers are both borne in mind, the figures show that the twisted nail made from square wire is superior to all others in all-round efficiency, next in order being the rusted nail and the twisted nails made from grooved wire. With the exception of the cement-coated twisted nails and a certain type of barbed and cement-coated barbed, the other types of nails showed no significant improvement over the plain nail.

*Pamphlet No.* 47.—"The Properties of Australian Timbers. Part. I. Eight Timbers of the Genus *Eucalyptus* (Ash Group)" (Division of Forest Products—Technical Paper No. 13). Collated and edited by H. E. Dadswell, M.Sc.

This Pamphlet is the first of a series in which it is proposed to record the available information regarding the properties and uses of the principal commercial timbers of Australia. The data it contains have been collected from various publications and from unpublished reports of the various sections of the Division of Forest Products. Data for each variety of timber are given under the headings of trade and vernacular names, habit and distribution, supplies, general characteristics of the wood, weight, moisture content, seasoning, durability and adaptability to preservative treatment, uses, chemical composition, and wood structure. Photomicrographs of transverse and tangential sections of each variety are also included.

## Forthcoming Publications of the Council.

At the present time, the following future publications of the Council are in the press:—

*Bulletin No.* 77.—"Studies in the Phosphorus Requirements of Sheep—I.," by Sir Charles J. Martin, M.D., D.Sc., F.R.S., and A. W. Peirce, B.Sc.

*Bulletin No.* 78.—"Methods for the Identification of the Pale or Light-coloured Woods of the genus *Eucalyptus*" (Division of Forest Products—Technical Paper No. 12), by H. E. Dadswell, M.Sc., Maisie Burnell, B.Sc., and Audrey M. Eckersley, M.Sc.

*Bulletin No.* 79.—"The 'Lucerne Flea' *Smynthurus viridis* L. (Collembola) in Australia," by J. Davidson, D.Sc., Head of the Entomology Department of the Waite Agricultural Research Institute, University of Adelaide.

*H. J. Green,*
*Govt. Printer, Melbourne.*